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REVENTIVE EDICINE

PRIZE ESSAYS

"THE GENERAL PRINCIPLES OF PREVENTIVE MEDICINE"

By W. Wayne Babcock, M. D.

"THE MEDICAL INSPECTION OF SCHOOLS: A PROBLEM IN PREVENTIVE MEDICINE"

By Lewis S. Somers, M. D.

PUBLISHED FOR GRATUITOUS DISTRIBUTION
TO THE MEDICAL PROFESSION BY
[redacted] E MALTINE COMPANY
BROOKLYN, N. Y.

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1903

INTRODUCTORY.

In January, 1902, The Maltine Company offered two cash prizes amounting to one thousand five hundred dollars for the two best essays on Preventive Medicine by issuing to the Medical Profession of the United States a circular embodying the following text:

Believing that a proper exercise of preventive medicine is of incalculable importance to the human race and desiring to stimulate further research in this line, or at least to disseminate some of the newer ideas so prominently discussed by the medical profession of recent years, we offer two prizes: a first prize of one thousand dollars and a second prize of five hundred dollars, in cash, for the best essays on that subject.

CONDITIONS OF THE COMPETITION:

First.—Essays offered in competition must treat the subject of Preventive Medicine in its various relations to the welfare of the human race, either treating the topic in its broadest scope as affected by disease, custom, environment, heredity, etc., or from the view-point of the specialist who contends that the most potent factors inimical to mankind result from special conditions which he is enlisted to combat.

Second.—In order that there may be no violation of medical ethics and no suspicion of mere commercialism on our part, Maltine or any of its combinations, ***must not be mentioned or even indirectly alluded to in the essay.***

14770

Third.—Competition is open to graduates of all recognized medical colleges.

Fourth.—The essays will be judged by the following gentlemen:

Daniel Lewis, A. M., M. D., New York, President New York State Board of Health; Professor of Special Surgery (Cancerous Diseases), Post Graduate Medical School; Surgeon to the Skin and Cancer Hospital; Editor "Medical Review of Reviews."

Chas. A. L. Reed, A. M., M. D., Cincinnati, Ex-President American Medical Association; Ex-President American Association of Obstetricians and Gynæcologists; Fellow British Gynæcological Society.

John Edwin Rhodes, A. M., M. D, Chicago, Associate Professor Diseases of the Chest, Throat and Nose, Rush Medical College; Former Professor of Physical Diagnosis and Clinical Medicine, Northwestern University Woman's Medical College.

and the prizes awarded in accordance with their decision.

Fifth.—The essays are to consist of at least ten thousand words.

Sixth.—Each competitor is to send us three typewritten copies of his essay by mail in a sealed envelope. These copies are not to be signed by the author, or contain anything which might point to his identity, but are to be signed with a *nom-de-plume*.

Seventh.—Another sealed envelope shall be sent to us containing this *nom-de-plume* together with the author's name and address. This envelope must be endorsed "For Identification," and will remain sealed until the judges have decided upon the two prize-winning essays, and will then be opened in order that the names of the successful competitors may be ascertained.

Eighth.—The prize essays and any others which are deemed suitable will be published in a medical journal or journals subject to the approval of the authors.

Ninth.—We reserve the right to republish any of these essays in pamphlet form, restricting the circulation to the medical profession.

Tenth.—Essays entered in competition must be in our hands by September the first, 1902.

THE MALTINE COMPANY,
8th Avenue and 18th Street,
BROOKLYN, NEW YORK.

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Drs. Lewis, Reed and Rhodes met for final deliberation and judgment in Buffalo on October 18th, 1902, and awarded the thousand dollar prize to " Alexine " and the five hundred dollar prize to " Broad."

Their formal decision follows:

BUFFALO, October 18, 1902.

TO THE MALTINE COMPANY,
New York.

GENTLEMEN:

Your Committee selected to award the two prizes offered by your firm for Essays on Preventive Medicine, or some subject connected therewith, begs leave to report that the large number offered in the competition, (being two hundred and nine in all), and the general high grade of their excellence, has made the matter of selection very difficult. After critical examination and mature deliberation, however, your committee has awarded the first prize to the essay entitled " The General Principles of Preventive Medicine," signed, " Alexine," and the second prize to the essay entitled " The Medical Inspection of Schools, a Problem in Preventive Medicine," signed " Broad."

In submitting this report the Committee congratulates you upon the wide spread interest which you have aroused in the very important subject of Preventive Medicine, and it congratulates the medical profession and the public upon the great good that will follow the publication of the valuable addition to literature thus evoked by your enterprise.

Respectfully submitted,

DANIEL LEWIS,
CHARLES A. L. REED,
JOHN EDWIN RHODES,
Committee.

" Alexine," the author of the essay which won the thousand dollar prize proved to be Dr. W. Wayne Babcock, of 3302 North Broad Street, Philadelphia, and " Broad," who won the five hundred dollar prize, Dr. Lewis S. Somers, 3554 North Broad Street, of the same city.

It is worthy of remark that both prize-winners are residents of Philadelphia, although two hundred and nine essays were entered in competition, the authors of which hail from forty-one different states and territories. A tabulated statement showing this distribution follows:

Alaska,	1
Arkansas,	1
California,	6
Colorado,	4
Connecticut,	5
District of Columbia,	3
Florida,	5
Georgia,	5
Illinois,	15
Indiana,	11
Iowa,	8
Kansas,	2
Kentucky,	3
Louisiana,	2
Maine,	4
Maryland,	2
Massachusetts,	12
Michigan,	7
Minnesota,	7
Mississippi,	1
Missouri,	5
Montana,	2
Nebraska,	2
New Hampshire,	1
New Jersey,	4
New York,	22
North Carolina,	1
Ohio,	11
Oregon,	1
Pennsylvania,	25
Rhode Island,	1
South Carolina,	2
Tennessee,	1
Texas,	2
Vermont,	1
Virginia,	1
Washington,	3
West Virginia,	2
Wisconsin,	10
Ontario,	2
New Brunswick,	1
Unidentified,	5
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Dr. Babcock's essay was published in *The Brooklyn Medical Journal*, and Dr. Somers' in *The Medical News*, and they are now reproduced in permanent book-form for the benefit of the Medical Profession.

The Maltine Company trusts that it has, in a measure at least, accomplished its object in instituting this competition: the stimulation of further research in the province of Preventive Medicine, or at least the dissemination of some of the newer ideas on that subject, in the belief that this would result in good to humanity.

AN ESSAY UPON THE GENERAL PRINCIPLES OF PREVENTIVE MEDICINE.

BY

W. WAYNE BABCOCK, M.D.,
Lecturer on Pathology and Bacteriology, Medico-Chirurgical College, Philadelphia; Pathologist, Kensington Hospital; Assistant Pathologist, Philadelphia Hospital, Etc.

Awarded the first prize of one thousand dollars
in the competition instituted by
The Maltine Company.

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Dr. W. V. GRIMES,

CHAPTER I.

THE ORIGIN OF DISEASE.

HEALTH AND DISEASE.

ORGANIZED beings are continually acted upon by their environment, and life is an expression of their continuous reaction. When reaction ceases, and the organism becomes the passive prey of surrounding forces, life is extinct, and has been succeeded by what is termed death. Living, the organism withstood the force of gravity and raised itself from the earth; maintained an equable temperature despite the surrounding alternations from heat to cold; retained the moisture of its tissues against the dessicating influence of the encircling air. Dead,—the organism falls to the earth, follows the temperature changes in the adjacent media, while the atmosphere filches its moisture and leaves it shrunken and misshapen.

In reacting against its environment, a living organism acquires its development, so that the ceaseless struggle immutably bound up with life is not without advantages. So long as the organism is able to maintain the equilibrium of its functions, the condition is described as *health*. All creatures, however, are only capable of reacting against a special and very limited environment, and the base of health's equilibrium is, therefore, a relatively narrow one.

Before an altitude of 9,000 meters is reached, the aeronaut succumbs to the rareified air and cold, while the immense weight of water crushes in upon the diver who dares brave the watery depths.

The human body withstands but limited variation in temperature, in the composition of atmosphere, in electrical influences and many other forces. By the artifices of civilization a broader environment has been secured for the human race, but too often these have interfered with the equilibrium of health. And so civilization and disease often go hand in hand, and it becomes the chief duty of the physician not to treat disease, but to point out how it may be prevented.

At once it becomes apparent how futile it is to try and restrict the race to a limited and innocuous environment. The clash from mailed fists will go in defiance of the Humanitarian; the Glutton, the Inebriate, the Profligate will persist despite the Reformer, and in the marts of trade where misdirected commercial zeal racks the nerves and ofttimes blasts the mind, the physician's warning voice will continue to go unheard.

Indeed, so lightly do we regard our health that, while Departments of War and of State and of Agriculture are considered essential, the safeguarding of our people from disease finds no place in the Cabinet—the Cabinet that conducts the affairs of our nation. And yet, although much of his effort goes unheeded, the true physician finds great satisfaction in the study and application of the principles of prevention, and can aspire to no higher tribute than that paid Edward Jenner by Thomas Jefferson—"You have erased from the calendar of human afflictions one of its greatest ——. Future nations will know by history alone that the loathsome smallpox has existed, and by you has been extirpated."

Prophylaxis.

Prophylaxis, the science of the preservation of health or the prevention of disease, is based upon our knowledge of the causation of disease, or *etiology*. This basis includes not merely the consideration of morbific agents, the manner of their diffusion, and the ways in which they invade and modify the living organism, but also a study of those modes of life that are prejudicial to the integrity of the body. Given a precise knowledge of the way in which a disease originates, measures of prevention may be readily formulated. The American Yellow Fever Commission gave us no new measure of prophylaxis, and yet they rendered it possible to eradicate a disease. We knew how to destroy mosquitoes and to prevent their bites, yet our sanitary measures against yellow fever were inefficient and we diffused and wasted our energies in an unsuccessful attempt to check its headway. With knowledge that the disease was mosquito borne, preventive measures were focalized against this insect, and soon Havana, perhaps for the first time in her history, was free from yellow fever. Likewise, it is less important that new prophylactic inoculations be devised against disease, than that we have a better knowledge of the nature of immunity. It follows that to prevent disease one must first grasp somewhat of its nature and origin, and knowing this, it will not be found difficult to develop a prophylaxis.

We shall, therefore, in our consideration of preventive medicine pay most attention to the more recent conceptions as to the nature of disease, and trust that where the application is omitted, the fertile mind of the reader may be stimulated to develop the appropriate preventive measure. Moreover, we concede the knowledge of our reader respecting the important general principles of personal hygiene and public health, of food, respiration, rest and exercise, of water supplies, sewage disposal, plumbing, building construction and like matters, and rather than reiterate the well-worn truths, will give them a briefer mention than their importance deserves. Again, even our imperfect knowledge of disease embraces so many observations that we can but hope to illustrate the broad underlying principles upon which the practice of preventive medicine rests.

Health may be said to express the harmonious reaction of the living organism to its environment. It is a relative, rather than an absolute condition, and implies the adaptability of the organism in structure and function to its surroundings. Of all organized beings, man shows the greatest ability to adjust himself to diverse environments, and for him the torrid atmosphere of the tropics, the extreme cold of the Arctic regions, the altitude of high mountains, the low level of plains, are alike compatible with perfect health. As health presupposes a structural and functional condition suited to the environment, and condition the reverse of this is properly considered an abnormality. *Disease* is structural or functional abnormality of the organism.

Diseases are characterized by metabolic nerversions occurring within the body, from the untoward action of physical, chemical or organized agents or psychic influences. The energy of casual factors, while important in the origin, are usually inconspicuous in the manifestations of disease. Thus, the force of the percussion cap is not appreciable in the effects of the explosion it incites. The manifestations of disease are not limited by the number of casual factors, but by the number of reactions that may be shown by the tissues. This we should not forget—that *disease expresses the reaction of the organism, not the action of the so-called "germ."*

When diseases result from microorganismal action, they are termed *infectious,* zymotic or spe-

cific diseases or *mycoses.* The attempt has been made to restrict the term "infectious" to diseases produced by bacteria alone; but this is unjustifiable. A number of the most characteristic *infectious diseases,* such as smallpox and yellow fever, may prove, as has malaria, to be due to an animal rather than a vegetable parasite. It seems best, therefore, to include among the infectious diseases, all those caused by living microorganisms, whether bacteria, molds, yeasts or the smaller animal parasites.

Infection, Contagion and *Inoculation.—Communicable* diseases are those transmissible from animal to animal. The term *infection* may be applied either to direct disease transmission or to transmission of an indirect character, as by means of air, water, soil and clothing; by many authors, however, it is restricted to the latter method. Such indirect transmission occurs in typhoid fever, cholera and dysentery. *Contagion* is a form of infection, implying the more direct mode of transmission, in which the disease is acquired through close proximity of the well to the sick. No lesion of the surface is required. Smallpox, typhus fever and scarlet fever are classed as contagious diseases. *Inoculation* occurs when the microorganism enters the body through a break or lesion in the skin or mucous membrane. Rabies, tetanus, syphilis and malaria are examples of *inoculable* diseases.

With the increase of knowledge of the infectious diseases these terms have a lessened value. There is no sharp line of distinction between infection, contagion and inoculation, for in a single disease any one of the three methods may be operative. For example, scarlet fever may be conveyed by milk, and therefore, by infection; by direct contact, or *contagion;* and by the subcutaneous injection of saliva from the infected into the well, or by *inoculation*. A classification, however, may be made from the predominant natural method of transmission for the special disease. Unfortunately, in a number of instances this is as yet obscure.

If a disease be continuously present in a locality, it is said to be *endemic*. Thus, until 1901 yellow fever was endemic in Havana.

"An *epidemic* is an outbreak of a communicable or infectious disease, affecting a dozen or more individuals in quick succession before the recovery of the first case, whether arising from a single focus or several foci in a neighborhood."

A *pandemic* is an epidemic covering a vast area of territory, perhaps the known globe, and involving great numbers of people. Influenza notably recurs as a pandemic, and the great pandemics of plague are especially impressed upon history.

Immunity and Susceptibility.

The health of an organism implies that it is not merely able to cope with the ordinary unfavorable factors that surround it, but that it also has an adaptability to other and less common unfavorable conditions. There is, therefore, a certain amount of normal reserve power fortifying the organism, although to a limited extent, against unusual morbific influences. When this excess of resisting power is apparent, it is termed *immunity* or *insusceptibility*. Immunity is always spoken of in relation to a given morbific influence. Not only does it vary in amount in different animals, and in different members of the same species, but it also varies in the same individual at different times; being modified by food, drugs, fatigue and other conditions. The successful prevention of disease depends upon the inhibition or restriction of the range of action of morbific factors, on the development of an immunity, or on the cooperation of these factors. If we consider health to be represented by a plus, and disease-producing conditions by a minus quantity, we may assume the possibility of adding immunity units, thus increasing the plus condition; or of adding minus morbific units, thus reducing or annulling the plus condition. As health factors we may mention nutritious food, pure air, and water, regulated exericise; as morbific factors we may indicate starvation, fatigue, grief and fear. Health will be maintained if the sum of immunity units exceeds that of the morbific factors.

Susceptibility or *predisposition* may be expressed as a great reduction, or absence of, the plus factors, while *immunity* indicates their relative excess. In the former condition, the action of a few morbific units will result in disease, while in the latter the active morbific factor may be large without any alteration in health.

Diathesis is a form of predisposition unusually inherited, characterized by a tendency to develop a certain disease at some period of life. It suggests that at some points the innate equilibrium of health is unstable. Thus, gouty diathesis, rheumatic diathesis, tuberculous diathesis, are terms indicating an apparent tendency of the possessors to develop gout, rheumatism or tuberculosis.

NOSOGENY.

In the *prevention* of disease it is necessary to take cognizance of the individual, not only before the onset, but also during the entire course of the malady. It is customary to divide the *development and progress of an infectious disease* into various stages, in each of which prophylaxis should play an important part; on the one hand, protecting the individual, and, on the other, the exposed community.

Exposure.—During the period in which the individual is exposed to the morbific agent, prophylaxsis should be directed to combat the action of the causal factor and to develop in the tissues a condition of resistance or immunity. The former is exemplified in the measures of *disinfection,* the latter in the methods of *prophylactic inoculation* or *vaccination.* For the benefit of the community, it may also be wise to keep under *surveillance* or *detention* one known to have been exposed.

Infection and Incubation.—With the entrance of the causal agent of the disease into the body, prophylactic inoculation often becomes valueless; for the development of the artificial immunity is usually so long delayed that it is not manifest until the height of the disease. Moreover, vaccination may then be dangerous, by increasing the sum total of toxic material in the body. It is possible at times, however, to destroy the causal factors in the affected organism during the period of incubation. Thus, in localized infections, excision or destruction of the focus of infection or the application of a parasiticide may prevent the development of the disease, or, again, the use of bactericidal serums or certain drugs may cause the dissolution of microorganisms that have entered the body. Thus, gonorrheal ophthalmia is avoided by the instillation of silver nitrate; septic wounds become antiseptic under antiseptic dressings; hydrophobia is said to be prevented from developing by the Pasteur inoculations; and malaria is arrested by the administration of quinine. If the disease be a very contagious one, *detention* is advisable during the period of incubation. Probably the danger of infection from the inoculated individual before the appearance of prodromal symptoms, with rare exceptions, as in diphtheria, is not great.

Prodromes and Invasion.—In certain diseases the measures just described may serve to abort the malady during its early manifestations. For example, in localized infections, complete incision, the application of germicides, or the employment of antitoxic and bactericidal serums, may cause a cessation of the disease. Neoplasms completely excised do not recur; the course of diphtheria or tetanus may be shortened by the use of the appropriate antitoxin.

Neurasthenia, melancholia and certain diathetic diseases, in their early stages, may be arrested; especially by careful regulation of diet, exercise and mode of life. From the period of development, if the disease be infectious or communicable, care should be taken by isolation, disinfection, and at times by quarantine, that the sick may not be a menace to their own or other communities. Patients suffering from certain mental affections, as paranoia, should be isolated for the protection of society; and this likewise, may be advisable to limit the spread of such communicable neuroses as hysteria and chorea.

Fastigium.—The disease having fully manifested itself, measures of prophylaxis to the individual give way to measures of treatment; but prophylaxis still has a part to play in protecting the community that environs the patient, and in many of the transmissible maladies protective measures having this end in view must be continued until the disease has entirely run its course, and, at times, for a period after recovery. Broadly speaking, prophylaxis also has a place in the prevention of *intercurrent affections* and *complications* during the course of the disease and in averting *relapses* or *sequels.* These phases of prevention, however, are usually considered in connection with the treatment of disease, and are beyond our present scope.

Termination.—Should the disease terminate in *death,* prophylaxis may still be required to prevent the body from becoming a source of danger to the living. It is thus evident that measures designed to prevent disease, although especially applicable before infection has taken place, and in the early stages, also have an important part to play during the entire course of the malady, and at times for a considerable period after its subsidence.

As has already been indicated, the essence of the prevention of disease is included in the knowledge of its cause, and, therefore, it is difficult to carry out rational prophylactic measures without considering the *origin of disease.*

ETIOLOGY.

It is customary to divide the factors involved in the causation of disease into (a) *predisposing* or *remote,* and (b) *exciting, determining* or *immediate* causes. The former, lower the vital resistance and favor the action of the latter, yet they often act interchangeably; so that what at one time is a predisposing cause, at another becomes a determining factor. Trauma is usually classed as an exciting cause, yet it is a powerful predisposing factor to many infections. Depressing hygienic conditions may, on the one hand, favor the invasion of the tubercle bacillus, and, on the other, may determine the renewed activity of an old and latent tuberculous focus. Indeed, the time, the method of action, and the condition of the tissue acted upon, rather than the nature of the factor in question, determine whether a cause be predisposing or exciting. The germ, therefore, is no more important than the tissues it invades. Again, the exciting factor of one disease may predispose to the development of a second disease; as shown by the tendency to septic infection in alcoholics, and to tuberculosis in diabetics and lepers, and following measles. It is not possible, therefore, to sharply demarcate between predisposing and exciting factors.

Method of Action of Causal Factors.

Predisposing agents all act by diminishing resistance or increasing susceptibility, and their own action can easily be circumvened by maintaining or increasing the normal immunity of the individual. This, in large part, may be accomplished by observing the well-recognized rules of hygiene. The *exciting causes* of infection are the animal or vegetable parasites, and by the methods of *asepsis* and *disinfection* it is often possible to exclude them or to neutralize their action.

The causes of disease may come from without, and be *external* or *extrinsic;* or may arise within the organism, and be *internal* or *intrinsic.* The external causes are much better understood than those that are internal, and, therefore, it is mainly against extrinsic factors that prophylactic measures have been developed. It is obvious, however, that the ultimate origin of all factors of disease is extrinsic. Intrinsic factors of disease of this age express extrinsic influences that acted upon former generations. Thus, the son's neurotic tendencies result from the father's dissipations.

CHAPTER II.

THE INTRINSIC FACTORS OF DISEASE.

Age.

At the extremes of life, childhood and old age, there is the greatest predisposition to disease. Yet those diseases that are common in childhood do not usually affect the aged, and conversely. The young in the lower animals show the greatest susceptibility to artificial infection, and clinical experience indicates that a similar condition as to certan infections exists in the human family. During the early months of life, however, there seems to be a lessened susceptibility to the eruptive fevers, and in the newborn the inoculation of vaccine virus may be without effect. Tuberculosis in children is more often widespread and rapidly progressive than in the adult, and shows a predilection for the lymphatics, bones, joints, and serous membranes rather than the lungs, which, as a rule, are primarily affected in adults (Louis's law). Apart from tuberculosis, the diseases due to dietetic causes, and certain skin affections, nursing babes show an exemption from infection, probably because of their limited environment. Immediately following babyhood there is a special liability to contract measles, scarlatina, chickenpox, rubella, and pertussis. Typhoid fever does not usually occur until youth or early adult life. Nervous reactions are more marked in early life, as is indicated by the tendency to chorea and the appearance of convulsive disorders from comparatively slight causes, while in the aged severe diseases often excite little reaction. If the adult has not an inherent immunity to the common exanthemata, he has usually acquired it by having had an attack during childhood or youth. He is now, however, exposed to the diseases incident to

THE PROPORTION OF SICK AND DEFECTIVES TO AGE. MASSACHUSETTS, JUNE 1, 1890.—(Billings.)

	Ratio per 1000.	
Ages	Males	Females
15 to 25	9.74	6.90
25 to 35	12.38	8.84
35 to 45	21.80	13.11
45 to 55	57.14	21.76
55 to 65	71.17	34.19
65 and over	96.41	60.84

occupation and dissipation. After thirty-five years predisposition to carcinoma, especially in certain persons, appears; and as age creeps on, the degenerative changes in the organs, especially the forms of arterio sclerosis involving the heart and blood-vessels, together with their secondary effects, such as hemiplegia, aneurism, and senile gangrene, are common, as are also gouty and rheumatic affections; there is an increased tendency to insanity; and pneumonia is so common in the aged as to have been described as the "natural end of old men."

THE RELATION OF AGE TO THE FATALITY OF DISEASES. COMPILED FROM THE RECORDS OF EIGHTEEN HOSPITALS, FOR FIFTEEN YEARS.—(Modified from Billings.)

Rate per 100 cases.

Ages	Pneumonia	Typhoid Fever	Consumption	Diphtheria
0—10	10.8	8.2	46.5	57.9
10—20	8.2	12.9	46.3	22.3
20—30	15.3	17.0	48.8	10.2
30—40	22.0	25.2	55.4	
40—50	30.2	33.5	57.7	
50—60	40.3	40.6	59.1	
60	57.1	65.6	62.8	

Despite the dangers incident to pregnancy, the death rate of women is usually less, and the expectation of life greater, than with men. This probably is due largely to the fact that men are more exposed to dissipation and accident, and are more commonly engaged in unhygienic occupations. Up to the fifteenth year the difference between the sexes as to morbidity and mortality is not strikingly apparent, but thereafter there is a marked preponderance among males of certain diseases, such as alcoholism and other forms of poisoning, typhoid fever, rheumatism, urinary and venereal diseases, and scleroses of various organs, including the liver, kidneys, and central nervous system.

Forms of anemia, cancer, peritonitis, and intrapelvic tumors having their origin in the sexual organs, are much more common in women. During pregancy existing tuberculous affections may be arrested, but following labor the disease may follow a rapid, progressive course. Pregnancy is associated with an increased resistance to many poisons, as is exampled by the comparative safety of chloroform anesthesia during labor. The menopause or the menstrual periods may be associated with attacks of nervous disorders, of erysipelas or other infection. Certain general diseases are chiefly manifest in men, as is hemophilia, or bleeder's disease, while osteomalacia usually affects women.

Race.

Racial types of immunity and predisposition to particular diseases have been observed both in the lower animals and in man. In animals the striking difference in the resistance to bacteria shown by the white mouse and field-mouse is particularly impressive. In the human race the freedom of the Japanese from scarlet fever, the immunity of the Chinese against cholera, and of the negro against malaria and yellow fever, are examples. On the other hand, measles and some of the other exanthemata that are mild in civilized races have a high mortality when they afflict certain of the savage types. Thus, in the epidemic of measles in the Fiji Islands in 1875, it caused the death of over one-fourth of the population. The Jew shows a special predisposition to diabetes, although he seems to possess a greater immunity than others against tuberculosis and other infectious diseases. Races accustomed to the more primitive modes of life are apt to succumb quickly to tuberculosis when brought under the influence of civilization; a fact frequently exemplified among civilized Indians and negroes, and especially among Eskimos brought to more civilized countries. A related form of immunity is that which is developed by the repeated exposure during urban life to certain diseases. Thus, few city dwellers reach adolescence without having had, or having been exposed to, diphtheria, scarlet fever, measles, or whooping-cough, and it is, therefore, not strange that in military camp regiments show a comparative immunity from these diseases while regiments composed of men from the country are, in general, susceptible. The immunity of the negro against yellow fever and malaria may have a similar basis, or be due to unrecognized infection during infancy.

Nervous Influences.

It is impossible to disassociate physical lesions from changes in the central nervous system. Lesions of one part of the body may, by nervous reflex, originate morbid changes in a distant part. Thus, chilling of one hand will reduce the temperature of the other; cutaneous irritations reflexly affect the kidneys and modify the output of urea. In turn, nervous impairments may originate structural and functional disorders. In the hypnotic state, erythema and even vesiculation of the skin have been induced by suggestion. Fright, grief, anxiety, exhaustion, rage, terror, gloom, inordinate ambition, great joy, and other mental perturbations may manifest themselves by such functional changes as blanching of the skin, polyuria, glycosuria, vomiting, syncope, diarrhea, convulsions and shock. In a number of the personages of history, since the time of Sophocles and Ananias, sudden death has followed *mental shock*. There is much clinical evidence that emotional excitement increases the susceptibility to infectious diseases as well as to melancholia and other mental disorders. Certain neurotic conditions are transmitted by imitation. Hysteria, neurasthenia, chorea, tetany and even epileptic attacks have originated from the mental impression produced by seeing an affected person. Alterations of the normal trophic mechanism may cause the development of poisonous products within the body; for example, the milk secreted by mothers immediately after severe fright may be highly toxic. Reflex muscular atrophy in excess of that due to disuse occurs in the muscles about the diseased joint. Mental impressions may produce dyschromias, as in cases of bleaching of the hair following grief or nervous shock. A similar condition may occur from neuritis, and the vesiculation and ulceration in herpes are usually attributed to changes in the nerve-trunks. The appearance of hepatic glycogen in the blood, and its excretion in the urine, are well-known results of injuries to a certain portion of the medulla oblongata, and may also follow prolonged mental strain.

The avoidance of injurious, and the employment of helpful psychic influences, play no mean part in the prevention of disease and in the correction of morbid conditions. It is to be regretted that present materialistic tendencies cause them so often to be overlooked or ignored except by charlatans.

HEREDITY AND DISEASE.

Abnormalities in the organism previous to birth may be the result of any one of a number of factors. First, the *germ-plasm* of the fertilized ovum may have acquired, from either paternal or maternal source, modifications of normal developmental tendencies or of structure, leading to disease of the embryo. Such abnormalities may be upon the side of deficiency or on the side of excess. For example, the germ-cells may be impressed with excessive vegetative tendencies leading to giantism or local hypertrophies, and such functional hyperactivities as result in epilepsy, neuralgias, etc.; while if the inherent developmental tendencies be insufficient, dwarfing, cleft palate, harelip, web fingers and other imperfections may result. Or, if the inherent functional activities be too feeble, idiocy, insanity, forms of neuroses and similar disorders may occur. These conditions, transmitted from parent to offspring in the germ-plasm, constitute true *hereditary disease.* The term heredity, however, is often misapplied to morbid conditions that have been acquired by the embryo through various *accidental* factors in its prenatal environment. Thus, the fetus is not exempt from mechanical injury from without, and its motility in the uterine cavity may produce twists and knots in the umibilical cord, or otherwise result in its own harm. Monstrosities have been artificially produced by mechanical interference during gestation.

Should the mother's blood contain *toxic* material, the result of disease or from ingested poison, a portion of this will usually pass into the fetal circulation. In the fetus, the proportion is always less than that in the maternal blood; and as the toxic substance must pass through the fetal liver before reaching the organs of the embryo, a part of the poison is destroyed, so that the fetus is usually much less affected than the mother. For this reason the fetus may for a number of minutes survive the death of the mother. In the lower animals the fetus has been found much less vulnerable to certain poisons than is the mother; so that it may live after the injection of a poison into its own tissues, while the mother dies from absorbing toxic substances through the placenta. From material toxemias, the fetus may have its tissues so impoverished that its development is imperfect. Thus, it has been found possible to produce monstrosities by the use of certain chemical measures, while hypoplasia of the circulatory and reproductive systems is not uncommon in children of parents with tuberculosis or other debilitating disease.

Finally, direct *infection* may take place through the placenta. Children have been born with the eruption of smallpox or measles, and with lesions of syphilis, pneumonia, tuberculosis and other diseases acquired during the latter months of pregnancy. As it seems improbable that a true infection can occur in the germ-plasm, these affections are to be considered as arising from causes extrinsic to the fetus, even though present in the maternal tissues; and thus, although congenital, they are not to be considered as true hereditary diseases. They evidently originate by the passage of pathogenic bacteria through the placenta.

A *congenital disease* is an abnormality existing at birth; and, therefore, may be caused by any modification of the developing ovum from the time of impregnation to the completion of labor. Such congenital conditions include intrauterine fractures, dislocations, amputations and specific diseases that are contracted through the placenta, or during the parturition. Congenital diseases may or may not be hereditary.

Hereditary may be *immediate,* as when the disease is also active in the parent; or it may be *remote,* as when the disease is latent in the parent, although active in some progenitor. In hæmophilia, the mother who transmits the defect is herself usually free from it; while the male members of the family suffer from bleeder's disease, but usually do not transmit it to their offspring. Criminals, idiots, and the insane may show in their physical conformation a resemblance to a lower race or even to the higher. This has been considered as a reversion to a more primitive type, or a very remote form of heredity and is termed *atavism.* Acromegaly has been similarly explained.

True heredity is the transmission of the disease itself. The condition existing when only the predisposition or tendency to develop a disease is passed on by parent to the child has been called *false heredity.* Such a condition may not manifest itself for many years after birth. Syphilitic keratitis often develops about the fifteenth or sixteenth year in children otherwise healthy, and yet absolutely indicates the transmission to the child of a germ-plasm modified by syphilis. Tuberculosis may develop in a number of the members of the same family about the period of adolescence, apparently from the hereditary transmission of a susceptible germ-plasm.

The Transmission of the Infectious Diseases through the Placenta.

That infectious organisms may pass through the uterine sinuses into the placental circulation, and so reach the fetus, has been demonstrated by the presence of smallpox and other infectious diseases in children at birth, and also by laboratory experimentation. This, however, is uncommon in nature. More frequently a disease in the mother gives rise to modifications in the embryo leading to immunity, and, conversely, an infected child in certain cases seems to give rise to a condition of immunity rather than of infection in the mother, and Lingard's experimental infection of rabbit fetuses in utero with anthrax were usually followed by immunity of the mother. This is especially demonstrated in syphilis, in which the nonsyphilitic child born of a syphilitic mother cannot be infected from nursing its diseased par-

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chains that have been active for generations tend to persist. In sexual conjugation, idioplasms with different lateral chain combinations and affinities unite, and there results an idioplasm not possessing the identical properties of either parent, but modified in character and constitution toward the constitution of either one or the other, according to the preponderance in number or chemical activity of the paternal or maternal molecules entering into combination. This hypothesis explains the transmission of a predisposition or a physical abnormality. The transmission may be by intoxication, the intoxication being represented by a combination of toxiferous molecules with the idioplasm, that is transmitted to the offspring. Parasyphilitic lesions in the offspring of the syphilitic are explained as a result of the transmission of an idioplasm chemically altered through parental infection.

Consanguineous marriages and *inbreeding are* dangerous from their tendency to accentuate family weaknesses. This risk increases with the deviation from the normal of those concerned. While the marriage of near relatives would not be unwise in the absence of family weaknesses, few civilized families are so fortunate. On the other hand, there is equal risk in marriage between persons having no known kinship of the same social class or inheriting similar morbid tendencies. Sterility, deaf-mutism, pigmentary retinitis or various physical malformations often follow consanguineous marriages. Those exceptionally intelligent or possessing genius are usually unequally developed, and if their intermarriage is not followed by sterility their weaker rather than their stronger qualities are likely to be transmitted to their offspring in the form of mental degeneration, idiocy or insanity. Conversely, genius is more apt to spring from parents of mediocre intelligence than from the gifted. Fortunately the law of natural selection promotes the union of the unlike and constantly tends to maintain an equilibrium. Susceptibility to disease or defective development in the offspring may result from existing disease or dystrophia in one or both parents, such as tuberculosis, syphilis, carcinoma, grave anemia, or the results of prolonged dissipation. Fournier studied the progeny following forty-three marriages in which either husband or wife had inherited syphilis. From the 143 pregnancies that followed, there were 43 abortions, 39 still births, and of the remaining children many showed stigmata of degeneration, dystrophia, or defects in physical development. From this it is evident that syphilis may leave as marked an impress upon the second generation as upon the first, and it is probable that the baneful effects are also continued to the third and fourth generations.

Youth or senility, and great disparity in ages of the parents also unfavorably influence the offspring, as may too rapidly repeated pregnancies.

Chronic intoxication in the parent as from alcohol, opium, lead, mercury or other poison may result in defective offspring, or if of sufficient degree, in sterility. Nervous and mental disorders are prone to be exaggerated by heredity. It is to be remembered that to the general tendencis of heredity exceptions are not infrequent.

ABNORMALITIES OF DEVELOPMENT.

The complicated differentiation of cells and growth of tissue following the fecundation of the ovum may favor the production of abnormalities. These are usually congenital rather than hereditary, and may develop after, as well as during, intrauterine life. Indeed, the developmental changes may occur after adolescence, as is seen in *acromegaly,* in which overgrowth of the face, feet and hands may begin at thirty or forty years and continue indefinitely. These abnormalities may be classed under excesses, deficiencies and perversions of development.

Excessive Development.

A general excess of development produces the so-called giants. These persons usually show diminished powers of resistance when compared with those of mean stature, and rarely are symmetric. Local excesses in development may occur from the increased functioning of a part of the body, as in hypertrophy of the heart from valvular disease; or from some obscure cause, possibly at times associated with disease of certain glandular organs—as in acromegaly, in which lesions of the pituitary gland are often found.

Deficient Development.

Dwarfing is a result of the general failure of the organism to reach its proper size. As with giants, dwarfs are rarely symmetric beings, nor are they endowed with the average stamina. The failures of tissues, organs, or members to reach their normal size are more common, and are termed *hypoplasias.* These conditions are often the result of deficient or abnormal use as well as of imperfect development. In chlorotic girls the cardiovascular and genital organs may remain infantile in type. Defective intrauterine development not infrequently produces marked abnormalities of the organism in children, as illustrated by the cleft palate and harelip that result from the failure of certain branchial clefts to close. Patulous urachus, exstrophy of the bladder, atresia of the anus, web fingers, delayed descent of the testicle, hermaphroditism, and similar conditions result from defective intrauterine development. If a member be lacking, the condition is called *aplasia;* it is exemplified in many forms of fetal monstrosities, as the headless (*acephalus*) and limbless (*amelus*) monsters.

Perverted Development.

There may also be displacements of contiguous members, as exemplified by cases of transposition of the viscera, or of blastodermic cells. To the latter is ascribed the formation of incomplete monsters or the presence of one organism within another (*inclusio fœtus in fœtu*) and the formation of certain tumors (*dermoids*).

Organs or parts of the body may be duplicated, as is shown in cases of double aortas, double vaginas, and *supernumerary parts,* especially fingers (*polydactylism*) and spleens.

The *prevention* of the congenital abnormalities of development is largely included in measures aimed to improve the social fabric, especially those that directly influence procreation. The importance of laws and educational training to prevent or regulate the marriage of the aged, the very young, the dissipated, the diseased; of criminals, degenerates, defectives and insane is sufficiently obvious, yet often difficult in application. In many of the United States the influence of consanguinity has led to laws that render the marriage of first cousins illegal. Proof of the health of the persons concerned should accompany application for the marriage license.

AUTOINTOXICATION.

Autointoxication is the condition that results when compounds formed by the organism react injuriously against it. The term has been broadly applied to include infectious and putrefactive processes, the result of bacterial action within the intestinal canal or the tissues, conditions that cannot be properly considered as self-intoxications.

1. *Faulty Elimination.*—Normal excrementitious products are sometimes retained within the body. Such a condition apparently occurs in uremia from excretory insufficiency of the renal cells. The suppression of perspiration, by coating the body-surface with an impermeable material, may produce sufficient retention of toxic substances to cause death. In certain conditions, normal emunctories may be insufficient to carry off an abnormal excess of effete products.

2. *Incomplete Chemical Transformation.*—The cellular nuclein seems normally to be converted into certain intermediate products, as xanthin, hypoxanthin and adenin, before its final oxidation into uric acid and urea. Such an oxidation being incomplete, the process may be arrested at any one of the intermediate stages, with the result that a substance much more toxic than uric acid is thrown upon the system. Horbaszewski's theory of gout is based upon this supposition. Injections of hypoxanthin and xanthin for a period of several months have been found to produce in animals granular degeneration of the epithelial cells of the kidney resembling that found in lead-poisoning. This degeneration did not follow when repeated injections of pure urea were substituted. The imperfect decomposition of acetone in the body is common in diabetics. Incomplete chemical transformation may be the result of:

(a) *Deficient glandular secretion;* as apparently occurs in pancreatic diabetes, in myxedema and Addison's disease, the result of extirpation or disease of the pancreas, thyroid gland or adrenals.

Castration in early life prevents the development of masculine parts.

(b) *Excessive or perverted glandular secretion.* This apparently occurs in exophthalmic goiter from excessive and possibly perverted, action of the thyroid gland.

(c) *Irregular absorption of products of digestion.* Normally, albumoses and peptones that are formed in the intestinal canal are reconverted into albumins before they enter the blood. Under certain conditions of faulty absorption, albumoses, peptones and perhaps other compounds resulting from digestive action, may enter the blood unchanged and produce decided toxic effects. Through certain disorders of the liver hepatic glycogen may pass into the blood and urine or the ingestion of sugars may be followed by glycosuria.

If the liver be shut out of the general circulation by an Eck's fistula (connecting the portal vein with the inferior vena cava), the ingestion of meats is followed by pronounced nervous disturbance and even death; resembling the symptoms produced when ammonium carbamate is introduced into the circulation. This salt appears to be a final product of tissue oxidation, and is converted by the liver into urea, in which form it is excreted by the kidneys. Chittenden considers it probable that uremia results from the retention of untransformed carbonic acid. Moreover, the liver has an important role in neutralizing absorbed poisonous compounds, and autointoxication resulting from hepatic insufficiency has been abscribed to be the cause of icterus gravis.

Alterations in innervation may greatly modify the activities of organs and lead to the formation of toxic compounds. Thus, mental emotion may render the milk toxic and the urinary toxicity may be increased by emotion or before an epileptic attack.

Acid Intoxications.

In a number of more or less obscure metabolic disorders there are freed from the fats or proteids of the body, acids abnormal in kind and quantity that may induce severe toxic phenomena. These include B-oxybuteric acid, its derivative diacetic acid, which are believed to cause diabetic and certain related forms of coma, lactic acid, sarcolactic acid, uric acid and other acids, excessive amounts of which may occur in the blood in rheumatism, gout and other disorders.

LEUCOMAINS.

Leucomains are basic chemical compounds, closely resembling the vegetable alkaloids, that are produced by the metabolic activities of the organism. It is difficult to differentiate them sharply from ptomains and similar compounds resulting from bacterial action, and it is not improbable that certain substances that have been extracted from tissues, and at present are believed to be leucomains, may in time prove to be bacterial products. A number of the leucomains are found not only in the human tissues, but may also be obtained from the lower animals, from the higher plants and from yeasts. From their chemical relations they have been divided into two groups, the *nucleinic* or *alloxuric* leucomains, and the *creatinic* leucomains.

The Nucleinic Leucomains.

Many of the leucomains seem to be derivatives of an important constituent of the nucleus of cells, called nuclein. In nephritis there is a diminution in the amount of nucleinic bases excreted in the urine; in leukemia it is much increased. Kossel and his pupils have shown that nuclein, upon the addition of water or dilute acid, may be decomposed into a number of important leucomains, including *adenin* (amidopurin), $C_5H_5N_5$, *guanin,* $C_5H_5N_5O$, *hypoxanthin,* $C_5H_4N_4O$ (sarkin), and *xanthin,* $C_5H_4N_4O_2$. These are closely related to uric acid, and have been termed *xanthin, alloxin* or *purin bases.* Cysnogen is shown in the chemical formula of nuclein and of its derivatives, but the reason for its intimate relation with the nuclein molecule is not understood. As a rule these are whitish, amorphous, crystalline solids, forming neutral solutions in water, in which they are slightly soluble. They are insoluble, or but slightly soluble, in ether, and have variable, but usually feeble, combining powers with alkalies and acids. Our knowledge of these leucomains is as yet very incomplete, and their relation to human pathology at present is largely conjectural. It is assumed that they are derived from a hypothetic substance, *purin,* $C_5H_4N_4$.

The Creatinic Leucomains.

These are closely related to the nucleinic bases, but show a chemical construction of a somewhat different type. They may be derived from muscular tissue and on decomposition they yield urea.

Creatin, $N(CH_3).CH_2.COOH$, which gives the name to the group, is derived from the muscle albumins of vertebrates, and occurs in the brain, thyroid gland, blood and urine.

Other creatinic leucomains are *creatinin,* $N(CH_3).CH_2CO$, the anhydrid of creatin,*arginin, lysatin,* $C_6H_{13}N_3O_2$, and *lysatinin,* $C_6H_{11}N_3O$.

Gautier has studied the leucomains found in fresh muscles, and has isolated a number of compounds, some of which are said to be intensely toxic. Little is definitely known of these latter, and the work requires amplification and corroboration. They include *crusocreatinin,* $C_5H_8N_4O$, which is closely related to creatin, and *xanthocreatinin,* $C_5H_{10}N_4O$, which is the most deadly of muscle leucomains. This produces in animals depression, somnolence, vomiting and diarrhea. It was found by Moroni in the muscles of an exhausted dog and in the urine of fatigued soldiers. It possibly has something to do with the subjective sensations of fatigue.

It is claimed by Gautier that leucomains are constantly being formed in the animal tissues and destroyed by oxidation. If not destroyed, poisonous effects may result.

CHAPTER III.

PHYSICAL.

THE EXTRINSIC FACTORS OF DISEASE.

Abnormal functional and structural alterations originating from agencies without the body are due to either physical or toxic agents, acting alone or in combination. They may be *unorganized,* as are all physical causes and the inorganic poisons; or *organized,* as are the vegetable and animal parasites and the poisons of vegetable or animal origin, and may act as predisposing or exciting factors of disease.

PHYSICAL CAUSES.

While properly all physical agencies play an important part in the maintenance of health, each may aid the induction of disease. Thus, mechanical violence, heat, cold, electricity, X-rays, atmospheric alterations, meteorologic and telluric conditions, may have an important action in the genesis of certain affections.

Mechanical Violence.

Mechanical agents include all forces that tend to change the condition of inertia of the whole or part of the body. If the excitation merely cause increased activity of a part, a true development or *hypertrophy* will usual follow; or if the activity become excessive, exhaustion may lead to *atrophy.* Frequently repeated or continuous slight irritations lead to overgrowth of tissue, or hyperplasia. Callosities developing upon the hands and corns upon the feet are examples of this condition. Inhalation of insoluble gritty particles are followed by fibroid changes in the lungs of coal-miners, grinders and polishers. In such conditions irritations may play an important part in predisposing to infection by the tubercle bacillus, the pneumococcus and other organisms. Continued pressure, if it be sufficient to interfere with the circulation in a part, may cause wasting, necrosis, or even gangrene.

Trauma or the abrupt application of mechanical violence may cause the disruption of tissues and the production of contusions, incised and lacerated wounds. Such a mechanical lesion expresses the result of a conflict between kinetic energy and resistance. The character of the injury may be the same whether the body-surface is the resisting force or the moving object. A blow may produce a lesion identical with that caused by a fall against a resisting substance. The result of mechanical violence depends upon the energy, the method of application of the force, and the character of the resistance. As the energy of a force is equal to one-half of the product of its mass into the square of its velocity, velocity is much more important than mass. The higher the velocity, the more strictly the injury is localized to the area of contact, and the greater is the destruction within this area. Bodies of low velocity that fail to traverse the tissues may have their energy entirely transmitted to the organism with which they come in contact, leading to more serious injury than that produced by bodies of greater velocity and force. High velocities give wounds of a clean-cut character; at lower velocities the tissues are pushed ahead and to the side of the moving object, so that the area of destruction progressively increases as the tissues are penetrated. For this reason the wound of exit is much larger than that of entrance.

Other things being equal, the character of injury varies greatly with the area of application. A force behind the keen edge of a knife may produce an incision with a minimum of tissue destruction, but with free hemorrhage. Blunt the cutting edge, and the area of tissue destruction widens. The hemorrhage is slightly less, and we have a slightly burised, torn, or contused wound. Broaden the edge of the instrument still more, and the contusion effect is more pronounced, but the depth of the injury lessened. Apply the same force over a broader surface, and a bruise or contusion, characterized by rupture of subcutaneous vessels, tissue filaments, and extravasations, occurs without any break in the skin. Apply the same energy over a much broader area, and the force may be so diffused that no injury results. Obliquity of action also decreases the destructive efficiency of mechanical energy.

The lesion produced by an incised wound, a contused wound, or a bruise may take its essential character from conditions within as well as those without the body. Thus, a sharp bony prominence may produce an incised wound of the tissues over it, when these come in contact with a plane surface, resembling an injury produced by a sharp instrument striking tissues over a plane bony surface. The force may be transmitted from the point struck and focus upon a distant area, where the chief lesion is found, as in fractures of the skull by *counterstroke*. The effects of mechanical violence vary with the function of the tissues injured.

Mechanical energy may be transmitted by gases and liquids as well as by solid substances. Thus, the terrible rending effects of violent explosives are produced directly by the enormous pressure of liberated gas; while explosive effects may follow the entrance of bullets into cavities that have rigid walls and liquid contents. The delicate nerve tissues may be severely injured by violent agitations or commotions, as in *commotio cerebri*.

General Effects.—Besides local lesions, severe *general effects* may result from local injury. The absorption of fibrin ferment or other substances from clean wounds may produce fever. Infected or poisonous wounds lead to general toxic changes. Mechanical violence may cause a general depression of bodily functions resulting in shock, fainting, delirium, maniacal excitement, or, at times, more permanent nervous lesions, such as hysteria, chorea, paralysis agitans and epilepsy.

Relation of Mechanical Injury to Infection.—Trauma has a very important bearing upon a number of *infectious processes*. Not only do open wounds afford a field for infection, but the growth and increase of virulence of certain pathogenic bacteria are favored by condensation and devitalization of the tissues. Besides this, injured tissues may, by permitting the growth of saprophytes, lead to the absorption of ptomains and the condition of so-called *sapremia*. The liability of inexperienced surgeons to have suppuration in their wounds is probably often due to partial devitalization of tissues from excessive handling and to anemia produced by too tightly drawn sutures, conditions that facilitate infection by microorganisms unable to invade tissues of undiminished vitality. Trauma seems often to determine the *localization* of circulating infectious particles, and experimentally it has been found that when tubercle bacilli are injected into the circulation of animals whose bones are contused, the tuberculous process often starts at the seat of injury. This also is illustrated in children in whom tuberculosis of the bones and joints often dates from a fall or blow. Local irritation is a predisposing factor in the determination of certain *tumors,* as carcinoma, and is believed to explain the position of epithelioma of the lower lip in clay-pipe smokers, of cancer of the scrotum in chimney-sweeps and in tar and paraffin workers, and of epithelioma of the cervix in multipara.

Heat.

The body is able to compensate for rises in temperature by increased evaporation of water. The respiration and heart action are hastened and the perspiration is increased. If the temperature exceeds 55° C. (130° F.), the normal heat-reducing mechanism becomes insufficient, and life is no longer possible, although for short periods of time temperatures of even 250° C. (400° F.) may by dry radiation be applied without injury to portions of the body. The exposure of the body to moderate increases in temperature leads to dilatation of the blood vessels and favors certain forms of infection. Thus, "taking cold" expresses an infection often the result of a *reduced immunity* due to overheating. More pronounced exposures to moderately high temperatures, especially when affecting the feeble, dissipated or fatigued, may lead to grave affections of the nervous system, known as insolation, heat exhaustion or thermic fever.

In cases of heat exhaustion the thermogenic centers are not involved, while in thermic fever there is marked hyper-pyrexia due to an inhibitory paralysis of the heat centers. Serious and even fatal degenerative changes in the neurons may result from the high temperature. Heat stroke may be followed by a permanent increased susceptibility to heat, characterized by vertigo, headache, digestive disorders or other symptoms on exposure to the direct rays of the sun or to high temperatures. More serious are forms of mental degeneration, epilepsy, general paralysis, mania, melancholia or idiocy that at times follows insolation. Often these serious results are to be taken as latent inherited weaknesses that have been precipitated by the high temperature.

Local Effects of Heat.—The local application of heat may result in (1) hyperemia, (2) extravasation of blood-serum with solution of certain cells (vesication), (3) coagulation of protoplasm (necrosis), (4) more or less complete oxidation or incineration. Thus, burns of the first, second, third and fourth degrees are differentiated. The local effects of heat are followed by certain systemic alterations that may be partly due to increased tissue waste, to retained or newly absorbed toxic products, or to bacterial invasion. Besides this, the suspension of function of important secretory or excretory organs may seriously affect the general system. Thus, it is found that localized burns, even though deep, are less serious than widespread superficial ones. In the latter case there may be destruction of the corpuscles of the blood (hemolysis), thrombosis and edemas, especially of the nervous system, and localized necroses in the internal organs. There is an increased destruction of albuminous substances in the body and a diminished elimination of carbon dioxid, with a tendency to fatty degenerations in the parenchymatous organs.

The Effects of Cold.

Moderate general or local cooling of the body has a powerful action in *increasing susceptibility* to many infections. Examples of this are seen in the common "colds," forms of pneumonia, nephritis, and enteritis following the chilling of the body-surface. After the *local* application of cold there is a hyperemia, but if the temperature of the tissues be markedly reduced, this is succeeded by a marked contraction of the blood vessels and anemia; until finally, when the tissues become frozen, they are dry and bloodless.

A part may be frozen for a brief period of time without especial injury. Upon thawing, an intense hyperemia succeeds the anemia, and may lead to rupture of blood vessels, thromboses, and extravasations into the tissues. For this reason the rapid warming of a frozen part is fraught with great danger. After prolonged freezing the cells fail to regain their functions upon the restoration of the normal temperature, the blood does not enter the involved area, and local death results. It is, therefore, possible to have a local necrosis directly from the cold itself, or from the secondary hyperemia and exudations following the exposure.

Lowering of the temperature of the *entire body* results in a diminished irritability of protoplasm, especially that of the nervous system, and finally death from the paralysis of vital centers. As the central nervous system is affected last, the serious nervous and mental sequels to heat stroke are not apt to follow exposure to cold.

Electricity.

Within certain limits, continuous, interrupted or alternating currents entering the body directly, through various conducting media, or by induction, produce structural and metabolic alterations. Effects result from the electric current directly from chemical compounds produced by *electrolytic action,* or from the transformation of the current into heat or other forms of energy. The effects vary with the character of the current, the amperage, the electromotive force, and the resistance of the tissues.

The human body offers a constant minimum resistance of about 3,000 ohms to the passage of electric currents. The resistance of the epidermis, especially if it be thick and dry, is marked, while the nervous tissues are comparatively good electric conductors. The intensity of the current is equal to the electromotive force (having as its unit the volt) divided by the resistance. The effects produced vary with the thoroughness of contact with the electric conductor and the thickness, dryness or moistness of the skin. The effect is also intensified by the passage of the current through the ground. As a rule, the alternating are more dangerous than the continuous currents, for in an alternating current of 500 volts the oscillation produces a difference in current potential equal to 1,000 volts. Alternating currents produce a minimum of electrolytic disassociation in the tissues, the alternations causing opposite chemical actions that tend to neutralize each other.

The effects of *sinusoidal currents* vary with the rapidity of the interruptions. Above 5,000 alternations a second, currents of many thousand volts may pass through the body without discomfort; while, should the number of alternations drop to between 200 to 500 in a second, death would result.

Electricity may *cause death* by the depression of vital centers, by local tissue destruction, or, according to d'Arsonval, by the heat produced by excessive muscular contraction.

Lightning stroke is most frequent in rural districts, where there are few facilities for the dissemination of the force. It frequently strikes a lone tree or other isolated conducting agent. Lightning may cause peculiar, dentritic, hyperemic lines on the skin.

Electric accidents from street currents may be *prevented* by thorough insulation, and by the use of rubber or other non-conducting gloves and shoes by the workmen. Linemen should be carefully instructed as to the proper method of handling live wires. Lightning rods protect buildings to which they are properly applied, except under rare circumstances. During thunderstorms the shelter of trees or other tall or isolated conductors should be especially avoided.

The Roentgen Ray.

The usual lesion from exposure to the X-ray (*Roentgenism*) is the so-called X-ray burn or *focus tube dermatitis.* This is a chronic inflammation of the skin characterized by erythema, pigmentation, hyperplasia, induration, alopecia, and at times ulceration and necrosis. These lesions are most pronounced over the area of entrance of the rays; but at times occur upon the corresponding opposite side of the member, the area of exit. The intervening tissues or organs may also suffer. The bones may develop an osteoplastic periostitis, and instances of cerebral and intro-abdominal disturbance are recorded. The lesions almost invariably follow prolonged or frequently repeated exposures, especially those made by tubes of *low vacuum* placed in close proximity to the tissues. Personal *idiosyncrasy* seems to be a predisposing factor. The method used for generating the electricity employed is immaterial.

The lesions are apparently due to trophic alterations in the tissue cells caused by the radiant energy. The incubation period varies from a few days to a month. Theories ascribing the disease to electric induction; de-electrification; the bombardment of the tissues by particles of platinum or glass; the generation of ozone in the skin; or ultra-violet rays, have either been disproved or have insufficient proof.

Prophylaxis.—The prevention of focus tube dermatitis consists chiefly in using tubes of the highest vacuum ("*hard tubes*") compatible with the resistance of the part of the body examined, and in avoiding a closer proximity of the tube to the skin than eight inches. A protective cover of sheet-rubber and the use of a grounded aluminum shield have been recommended, but, at most, are only partially effective. The operator should avoid unnecessary exposure, especially when starting or stopping the current. There is less danger when the rays strike the skin obliquely. Single, skillful applications should not be followed by dermatitis, but it is difficult to prevent lesions in operators or others who are repeatedly exposed to the rays.

Becquerel's Rays.

In 1896 M. Becquerel discovered that certain uranium salts emit invisible radiant energy resembling the X-rays. Later investigations by Madame Curie have shown that the pitchblendes, chacocite, autunite, cleveite, monazite and other minerals also possess radiant energy. In pitchblende, a substance (polonium) analagous to bismuth, but having 4,000 times the radiant energy of uranium, was found. Later a second ray-emitting element, called radium, was also discovered, and M. Debserne found in pitchblende a third active body, actinum. These rays possess luminosity and actinic and skiagraphic power, and render the air through which they pass a conductor of electricity. They are not capable of polarization, reflection or refraction, and the rays emitted by the different substances vary in their properties. They excite the phosphorescence of gems. Walkoff and Geisel first noted that energetic action of the Becquerel's rays upon tissues to which the radiant substances are brought in close proximity, and this has since been confirmed by Becquerel and Mme. Curie. The skin becomes hard and painful, and erythema, desquamation, and chronic ulceration have resulted from prolonged exposure to radiferous substances. The burns may persist for months, and have resulted from carrying tubes containing active radiferous barium chlorid and other substances in the pocket. The changes resemble those produced by the cathode or solar rays.

Light.

Solar rays (sunlight) have a marked influence upon the general nutrition, increasing tissue oxidation and the elimination of carbon dioxid. The pleasanter emotions are enhanced, and gloom and terror may be dissipated by light. Reflexly, more or less persistent forms of hyperemia and other phenomena may result, while different stages of hypnosis have repeatedly been produced by gazing *at luminous* objects. Locally, they alter the accumulation of pigment in the skin, causing freckles and tan. If the action be more intense or prolonged, erythema, desquamation, vesiculation, and even superficial eschars may result except in the habituated. Mucous membranes are susceptible. Snow blindness and gold blindness express the injurious results of strong reflected light upon the retina, while conjunctivitis, blepharitis and other ocular disorders may also be produced. The ultra violet rays are chiefly responsible for these various lesions. The thickness of the skull in certain Ethiopians has been attributed to prolonged exposure to intense solar rays, and the dark-skinned races of the tropics apparently bear evolutionary evidence of the effects of habitual exposure to sunlight. Of especial importance is the influence of sunlight upon immunity. Exposure to the solar rays not only reduces the liability to infection, but has shown a curative action in cases of lupus, pulmonary tuberculosis and other diseases. In such cases the ultra violet rays are effective, not only by a direct bactericidal action, but also by increasing the blood supply and stimulating tissue resistance. Light rays may traverse nearly any of the tissues of the body. Thus, photographs have been printed by light that has passed through the thorax or abdomen. The eyes may be protected from the injurious effects of light by appropriately colored glasses. Those exposed to intense white light should wear smoked glasses, while it is advised that workers on gold should wear glasses having a green tint.

The *electric light* may produce similar cutaneous lesions. Although the solar rays have an energetic action after passing millions of miles, the electric light is active only within a few meters, the *cathode rays* only within a few centimeters, and Becquerel's rays only within a few millimeters.

Sound.

Auditory impressions have a marked effect upon the higher cerebral centers in the way of exaltation or depression. Nervous excitation, joy, or moroseness may result from certain discordant or musical sounds. The street noises of large cities by constant nervous stimulation may predispose to neurasthenia, hysteria and chorea. The absence of sound, silence, favors abstract thought and melancholy, and is probably a factor in the prevalence of insanity in rural regions. Racking, irritating noises cause insomnia, while the continued repetition of monotonous sounds often has a soporific influence. Various degrees of hypnosis may be produced by auditory sensations, as the cataleptic conditions Charcot evolved at the Salpetriere by the stroke of a bell. Finally, certain sounds produce remote functional effects, as the irresistible desire to urinate that sometimes rseults from the sound of running water. Not only is it important that the street noises of cities be restricted by methods of paving, regulation of traffic and other measures; but the employment of harmonious sounds for the relief of insomnia, nervous excitement and various mental affections should have a wider application.

CHAPTER IV.

THE EXTRINSIC FACTORS OF DISEASE.

PHYSICAL—Continued.

THE ATMOSPHERE.

Animal life is dependent upon free *oxygen* as contained in the air. Imperfect supply of oxygen to the tissues produces fatty and other degenerative changes, and increases the susceptibility to infection. Complete deprivation of air is followed by a rapid and fatal asphyxia.

Composition.

Air is a mechanical mixture of various gases, the relative proportions of which are very closely maintained over all portions of the globe and at different altitudes. The average composition by volume is:

Oxygen..........	20.96 per cent.
Nitrogen.........	79. per cent.
Carbon dioxide...	0.04 per cent.
Argon...........	0.75 per cent.

Ammonia, oxone, nitrous and nitric acids, slight traces. There are also minute amounts of other elements, such as kypton, neon and xenon, discovered by Ramsay, and coronium, discovered by Nasini, which have unknown properties, and at present are interesting only scientifically. Besides these elements, air contains a variable amount of aqueous vapor.

Oxygen.—A large number of analyses of outdoor air show that the proportion of oxygen by volume varies from 20.92 to 20.99 per cent. The proportion is slightly less at great heights and in towns than in the country or on the sea. In man the oxygen is taken from the air by the hemoglobin, in which combination the oxygen is carried by the red blood corpuscles to the tissue cells. These cells return the oxygen to the blood in the form of carbon dioxid, and it is chiefly eliminated as such in the expired air. Inspired air loses about one-quarter of its oxygen. Large quantities of oxygen are also utilized in various inanimate processes of oxidation and combustion. The resulting carbon dioxid is chiefly absorbed by plants through the action of chlorophyl, free oxygen being returned to the air. The well-known law of diffusion of gases, which is that a gas expands and diffuses as freely in the presence of another gas as in a vacuum, accounts for the maintenance of the usual proportion of oxygen. The average quantity of oxygen absorbed daily by an adult is about two pounds, this amount being increased under conditions of activity and diminished during repose and old age. A sufficient reduction in the total amount of oxygen in the air, irrespective of the quantity of other constituents, leads to asphyxiation.

Nitrogen.—The nitrogen of the air seems to have no active part in the physiologic chemistry of the body. The same amount is found in expired as in inspired air. It serves as an inert diluent for the oxygen. While the animal kingdom seems unable to utilize nitrogen in its economy, a few microorganisms are able to produce combinations with it, forming nitrites and nitrates. Plants, especially the legumes, take the nitrates formed by microorganisms and convert them into albuminous compounds that may serve as food for the higher animals.

Argon.—Argon, discovered in 1894 by Rayleigh and Ramsay, has no known action in the economy. Chemically it seems to be extremely inert, and it is with difficulty that any combination can be produced with it.

Carbon Dioxid.—The amount of carbonic acid gas in the air is much more variable than either oxygen or nitrogen. The average amount in pure air is about 0.03 per cent., but on mountain tops, as little as 0.017 per cent. has been found. In parts of Death Valley, California, there is such an excess that the air will not maintain animal life. It results from the oxidation of organic matter, and is, therefore, produced in all animal bodies; and in most processes of combustion, decay and decomposition. It is found in the air in larger quantities at night than during the day. The largest amounts occur during the autumn, the smallest during the winter. It is removed from the atmosphere by the action of plants, and by absorption in water, which is able to take up its own volume of the gas. Inspired air should never contain more than 7 parts in 10,000, yet in buildings crowded with people, the amount may reach as high as 40 to 50 parts in 10,000. The objection to carbon dioxid is not that it is a poison, for it seems of itself to be inert, but that it displaces oxygen; while if its amount in the inspired air is such as to nearly or quite equal in tension that of the carbonic acid in the venous blood, the blood is less able to give up this gas, and the normal process of oxygenation is incomplete. It is a popular belief that the expired air contains certain organic impurities, and that the percentage of carbon dioxid serves as an indicator of the proportion of these supposedly toxic compounds. While the exhaled substances may have disagreeable and depressing odors, they seem to possess little toxic action.

Ozone.—Ozone is the allotropic form of oxygen in which the molecule is supposed to contain three atoms. It has a peculiar, pungent, garlic-like odor and much stronger oxidizing powers than oxygen. In the air it is rarely found in amounts greater than one in 700,000. It is more abundant at the seashore, on mountains, and near woods. In proportions greater than 4 in 1,000, it produces a marked irritation of the respiratory mucous membrane and death in the lower animals subjected to it. Its value as a health restorer is apparently overrated. When present in the atmosphere, however, it indicates a comparative freedom from organic or other oxidizable matters.

Ammonia.—This is the chief product of the decomposition of nitrogenous organic material. It is found in largest amounts where large quantities of manure or other decomposing organic substances are present. It is precipitated from the air in watery vapor, and is also removed by combinations leading to the production of nitrites and nitrates. In excess it suggests the presence of an unwholesome decomposition process in the neighborhood.

Aqueous Vapors.

Humidity is a term referring to the amount of aqueous vapor suspended in the air. It is usually expressed by relative terms, as the amount of vapor that the air will take up varies at different temperatures. Thus, at 0° C., the air can hold 1-160 of its weight of aqueous vapor, and this amount is doubled by every rise of 15 degrees in temperature. At 15° C., therefore, it will take up twice as much as at 0° C., or 1-80 of its weight, and so on. When the air at any temperature is saturated, it is said to have a relative humidity of 100. If it is one-fourth saturated with aqueous vapor, the humidity is 25. If the aqueous vapor equals one-half the amount necessary for saturation, the humidity is termed 50. It is obvious that with a decrease in temperature the amount of aqueous vapor necessary to represent saturation, or 100 degrees humidity, rapidly diminishes, and that as soon as the aqueous vapor is in excess of the amount necessary for saturation, it is precipitated. Precipitation may also occur when the humidity is much below the point of saturation, through the action of dust, electric currents, and other agencies. Humidity is of special importance in relation to the perspiration. With low temperatures the sweat usually evaporates as rapidly as it is eliminated, so that only

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insensible perspiration occurs. As the humidity increases, the transpiration of sweat may go on as before, but the evaporation is progressively retarded until at 100 degrees humidity there is no evaporation and the skin remains constantly wet. This reduction in evaporation diminishes the natural heat dissipation, and also greatly favors heat conduction, so that with a high relative humidity, low or high degrees of temperature are poorly borne, and the extremes of temperature compatible with life more circumscribed. Great humidity, by interfering with the normal heat regulation of the body, may indirectly favor the taking of "colds" and the development of many of the infectious processes. The presence of aqueous vapor in the air serves a useful purpose by absorbing the heat from the sun during the day and by retarding evaporation and consequent heat dissipation from the earth at night. Consequently, while it intensifies the effect of heat and cold, it modifies sudden temperature changes.

Toxic Gases.

The most harmful of the gases found in the atmosphere is *carbon monoxid,* CO. This is found in large quantities in illuminating gas, and is given off in the burning of coal and charcoal. When sufficient oxygen is present for complete combustion, it burns with the formation of the comparatively harmless carbon dioxid, CO_2, and this combustion is the cause of the blue flame so often seen playing over coal fires. Should the supply of oxygen be insufficient in the burning of coal, charcoal, kerosene, or illuminating gas, portions of carbon monoxid may escape into the air, and as it is odorless, may be inhaled with serious results. Cast-iron stoves, when red-hot, absorb from burning coal considerable quantities of the gas and may give off small amounts to the air.

When inhaled, it unites with the hemoglobin of the blood, forming *carboxyhemoglobin*, a compound not decomposed by oxygen and carbon dioxid. The blood may turn a cherry red color. Death results from asphyxiation. One of the most frequent forms of serious poisonings in the United States depends upon the intentional or accidental inhalation of illuminating gas. As water-gas contains about six times as much carbon monoxid as coal gas, it is the more dangerous. Leaky fixtures are often present, or the gas may travel long distances underground from defective mains, and from the cellar penetrate the house. In the passage of illuminating gas through the soil, the odorous portion may be largely absorbed, rendering the contamination of the atmosphere more difficult to detect.

Detection of Carbon Monoxid.—Fresh blood exposed to the air and then examined by the spectroscope will show if carbon monoxid be present, the two characteristic absorption bands of carboxyhemoglobin; but these will not be altered when a reducing agent such as ammonium sulphid is added to the blood. In normal unexposed blood the reducing agent will change the double bands to a single intermediate one.

Many noxious substances are added to the air in the prosecution of various trades and manufactures. The vapor or solid particles of mercury, arsenic, phosphorus, zinc, lead, or other compounds, or certain acids are especially harmful. The presence of vapors from sulphuric acid in the air is comparatively harmless, but the vapors of fluorine, chlorine, bromine or iodine produce serious inflammations of exposed mucous membranes and the skin.

Mine Air.

Especially noxious is the air in mines, which is deficient in oxygen and contains an excessive amount of carbon dioxid, together with carbon monoxid, methane, hydrogen and hydrogen sulphid. The latter gases, together with the fine carbon dust in the air, are combustible, while methane constitutes the dreaded *fire-damp* that may lead to serious explosions. Should death not result from the explosion of the fire-damp, it may be caused by the deficiency of oxygen, and the presence of carbon monoxid and hydrogen sulphid in the *"after-damp." "Black-damp,"* or *"choke-damp,"* results from the slow oxidation of the carbon and hydrogen of coal by the oxygen in the air. It extinguishes fire and may lead to fatal asphyxia. Undiluted, it consists of nitrogen and carbon dioxid. Mine air is rendered respirable by the continuous employment of ventilating appliances.

Sewer Air.

In the decomposition of sewage, large quantities of carbon dioxid, with some marsh-gas, ammonium compounds, and hydrogen sulphid are given off. In unventilated cess-pools these gases, and especially the ammonium sulphid, are often present in such large amounts as to jeopardize life, and it is the custom of workers before entering such pits to introduce lighted candles as a test of the ability of the contained air to sustain life. If the lamp is extinguished, the air is, of course, considered to be irrespirable. In the modern ventilated conduits and mains for sewage the air rarely contains sufficient carbon dioxid or other gases to be prejudicial to life. Carbon dioxid is usually present in from 10 to 50 volumes in 10,000, and in sewers without ventilation the quantity is, of course, much greater. Efficient *ventilation of* sewers rarely causes serious contamination of the external air, and it is preferable that the gases escape into the open air and be largely diluted, rather than be retained in the sewage system and by defective plumbing enter houses in considerable quantities. The experimental evidence as to the influence of this gas upon infection is contradictory. Moderate quantities of sewer air from a well-ventilated system are probably without appreciable effect, while larger quantities of this air but little diluted may depress resistance of the body and thereby favor the entrance and growth of morbific agents.

The pathological condition resulting from the inhalation of emanations from decomposing animal matter is termed ***mephitism.***

Solid Particles in the Air.—Dust forms an essential but ofttimes harmful ingredient of the air. It is useful to the formation of clouds and mist and in regulating the precipitation of moisture. It consists of a multitude of organic and inorganic, animate and inanimate particles, the number being modified by the locality, the humidity, by winds, various industries and other agencies. Aitkin found from 8,000 to 100,000 dust particles in each cubic inch of air in the country, while there were 1,000,000 to 50,000,000 particles in city air. When the air contains large quantities of inorganic particles these may be deposited in the lungs with the production of pneumonokoniosis. The number of *bacteria* present in the air is subject to wide variations. At high altitudes and in mid-ocean, few or no bacteria are found. In general the number bears a direct relationship to population, overcrowding and lack of sanitation.

The following table from Miquel, quoted by Roger, illustrates the great variations in the number of bacteria found in different localities:

NUMBER OF BACTERIA FOUND IN A CUBIC METER OF AIR.

In the sea, at 100 kilometers from the coast	0.6
Altitude of 2,000 meters	3.
Summit of Pantheon	200.
Observatory of Montsouris	480.
Rivoli Street (in Paris)	3,480.
New house	4,500.
The air of sewers of Paris	6,000.
Old house	36,000.
Hotel-dieu (hospital)	40,000.
Pitie Hospital	79,000.

Fortunately, the most of these bacteria are molds or harmless micrococci. Rains, snowstorms and high degrees of humidity greatly reduce the number of bacteria in the air, and the number is less at night than during the day, during the winter than the summer time. Through desiccation and the action of the sun's rays these floating microorganisms are constantly being destroyed.

Aerial Infection.—The early theories as to the method of disease transmission assumed the presence in the air of a vaporous principle or miasm, which rose from the earth or water, or was given off from the sick. We now know that the infectious diseases are not conveyed by gaseous principles. With the proof that malaria is transmitted by mosquitoes, the last of the so-called miasmatic diseases has passed out of the nomenclature, and it may be definitely said that the term miasm has only an historic place in scientific literature. The theory of infectious diseases attributing their origin to definite, organized particles, implies that the air must contain particles of a liquid mist or of dust in order to transmit these diseases.

Many experiments have shown that bacteria are not ordinarily given off to the air from moist surfaces. In exceptional cases by the action of violent winds, distinct particles of water with bacteria inclosed may be picked up and carried. In the vaporization of water, although the aqueous vapor may also immediately condense after entering the air, the definite interval in which it is in the form of a gas prevents it from carrying bacteria from the liquid. When, however, in fermenting liquids there is gaseous evolution, with rupture of bubbles upon the surface, minute particles of the liquid may be thrown into the air in the rupture of these bubbles. It has been assumed that in this way *sewer air* may be contaminated from sewage, but practically it is improbable that these particles remain in the air for a sufficient length of time to be an important factor in disease transmission. Their specific gravity causes them soon to fall again to the ground or to the surface of the liquid.

Moreover, sewer air contains comparatively small numbers of bacteria, and these usually differ in type from those predominant in the sewage, while men employed in sewage systems and breathing sewer air many hours daily, not infrequently exceed the average laborer in health and vigor.

From the moist surface of the respiratory tract of man and animals liquid particles are ejected by the acts of coughing, sneezing and speaking. The experiments of Flugge and others have shown that these particles remain suspended in the air for a distance of several meters (20 feet), and then rapidly subside by gravitation. As would be expected, greater numbers of watery particles are thrown off from those speaking the guttural tongues, and in coughing, while in ordinary, quiet respiration no bacteria seem to leave the mucous surfaces. Infection may thus be carried by particles of liquid, the air simply serving as the medium through which they are propelled. The number of diseases in which infection occurs in this manner is not great, the *tubercle bacillus* being one of the most important organisms thus transmitted. *Diphtheria* has repeatedly been conveyed to physicians and nurses by the patients' coughing in their faces during the examination of the throat. As the cause of *scarlet fever* is known to be present in the saliva, this may also be transmitted in a similar manner, as may be the case with *pneumonia, influenza, measles* and *plague*. There is little reason to believe that such diseases as cholera, typhoid fever or yellow fever are often diffused in this way; and it is obvious that for the occurrence of this form of infection the exposed person must be in close proximity to the one affected.

This method of transmission is to be *avoided;* first, by care upon the part of the patient, who should place a handkerchief over the mouth during the act of coughing, and second, by care upon the part of those engaged in the examination of the throats of patients suffering from diphtheria or scarlet fever, who should use a glass screen or other protective device. As the saliva of most individuals contains pathogenic organisms, the present tendency of surgeons to avoid talking over the operative field, and to wear pieces of gauze or other material over the lower portion of the face, has a sound basis. The important matter is to know how long disease organisms may remain infective after having been thrown into the air. It is probable that tubercle bacilli, especially when inclosed in particles of sputum, may retain their virulence for months, as has been demonstrated experimentally by the infection of guinea-pigs with dust from rooms previously used by consumptives. The pyogenic cocci resist drying for a considerable time, and yet the fact that wound infection from the air by these organisms very rarely occurs shows that they must rapidly fall to the ground. The colon bacillus, and the organisms of typhoid fever and cholera, quickly die upon drying, and, therefore, require no special precautions to prevent their transmission through the air, except by insects or enclosed in liquid particles. Inoculation with the bacillus of typhoid fever from flying liquid particles has apparently occurred in the washing of clothes and in the performance of autopsies. As Jehle found the bacillus typhosus in the sputum of most patients with pneumonia complicating typhoid fever, care should be taken to prevent the diffusion of secretion from the respiratory tract in cases of typhoid fever associated with pulmonary exudation. *Dust particles* floating in the air contain many microorganisms, but these consist almost entirely of molds, yeasts and saprophytic cocci. It is only when there is quite a violent commotion of the air that pathogenic organisms seem to be carried in the dust, and then the fact that many organisms die upon thorough drying, reduces the liability of infection from such sources. The street dust of cities, laden as it often is with excrementitious particles from man and the lower animals, and carried by the wind into the eyes and upper respiratory passages of persons exposed, is probably the orgin of many of the milder catarrhal affections prevalent in the spring and fall, and may also be the origin of tuberculosis or other grave infection.

The important action of sunlight, and of fresh oxygen, as provided by thorough ventilation, in increasing the purity of air and reducing the danger of infection from this medium, is constantly to be borne in mind. Dependence should not be placed upon these natural methods, but sanitary rules should be enforced to limit the contamination of air.

ATMOSPHERIC PRESSURE.

At the sea-level the weight of the atmosphere is 1.03 kilos to each square centimeter, or 14.64 pounds to the square inch. This is equivalent to a barometric height of 760 millimeters, or 29.92 inches, at the freezing point. The human body sustains under these conditions a total pressure of about 18,000 kilos, or 39.683 pounds. The balance between the pressure within the body and that from without permits the support of this vast weight without discomfort. Changes in the external pressure, especially when occurring so rapidly as to interfere with the normal pressure equilibrium, may be followed by symptoms, as exemplified in *barometric neurosis* and *caisson disease*.

Natural barometric fluctuations result from difference in altitude, temperature, humidity and winds. They may be periodic, as are the *diurnal* and *annual variations*, or non-periodic, as are the cyclonic and *anti-cyclonic* variations.

Increased Atmospheric Pressure.

A marked increase in the atmospheric pressure, especiallv if frequently repeated, often produces bleeding from the nose, ears and other mucous membranes, delirium, and forms of paralysis. Degenerations in the central nervous system and vacuolations in the spinal cord have been found. The symptoms appear upon the rapid return to the normal pressure, and the vacuolations have been attributed to the sudden expansion of condensed gases contained in the nerve-tissues. The group of symptoms produced by increased atmospheric pressure has been termed *caisson disease,* as it especially occurs in those working in caissons, and in divers. The condition may be prevented by avoiding sudden changes in the atmospheric pressure. Workers in the caissons should spend at least five minutes in an intermediate chamber, for each six pounds change in pressure, both on entering the caisson and upon leaving it.

Decreased Atmospheric Pressure.

Dyspnea and nervous excitement, faintness, cyanosis, hemorrhage and vomiting may develop when high altitudes are reached. These symptoms occur in mountain climbers and balloonists. There is in the blood a decided increase in the number of red blood corpuscles, followed by an increase in specific gravity and hemoglobin. Similar conditions may be produced by placing animals in chambers from which the air is partially expelled. A return to the normal barometric pressure (760 mm.) causes a transient decrease followed by an increase of the red cells over the number present previous to the experiment. Ossian, Schaumann and Rosenquest found that the microcytes were diminished, the macrocytes increased, and the cells of average size unchanged in number. There was a slight increase in the number of nucleated cells, and in pigeons mitotic figures occurred in the red cells. These changes were found in the blood from the liver, aorta and skin, and suggested to these observers that there was a true proliferation of the blood-cells. The increase of hemoglobin was not proportionate to that of the number of erythrocytes.

Mountain Sickness.—This may occur at a height of 3,000 meters (9,750 feet), but is most common at 4,000 meters, especially when associated with cold. Thus, the ascent of mountains with a high zone of perpetual snow, like the Andes, Rockies and Himalayas, less often produces mountain sickness than does the ascent of mountains in which the snow line is lower, as the Alps. It is more common when the ascent is made rapidly by unaccustomed climbers, who become overfatigued. Fatigue, while an intensifying factor, is not essential, as mountain sickness occurs in aeronauts and in those who ascend Pike's Peak by train. Pains in the legs, salivation, nausea, vomiting and even tormina and diarrhea may develop. The respirations are accelerated, the pulse is rapid and feeble, the surface becomes cold and clammy. Vertigo, headache, and finally apathy and an almost irresistible tendency to sleep may develop. The experiments of Paul Bert indicate that it is not the mere rarefaction, but the diminution in the oxygen of the air, that is the cause of the disease. At high altitudes the diminution in temperature adds to the injurious effects from the lack of oxygen.

WATER.

Water may become a factor in the production of disease when it contains harmful amounts of mineral matter, toxic organic compounds, or serves to convey pathogenic organisms to the body. Gout, rheumatism, myxedema and other disorders have been attributed to mineral matters contained in drinking water, but the relationship of these disorders to the water has not been clearly proven.

Injurious quantities of inorganic or organic matter in water may easily be determined by comparatively simple tests, and may be avoided by careful selection of sources of water supply and the method of distribution. More important is the relationship of water to the dissemination of organisms capable of exciting disease.

The Contamination of Drinking Water.

The chief infections believed to be transmitted by drinking water are *typhoid fever* and *cholera.*

The organisms of both these diseases have been demonstrated in waters used for drinking, and their relationship to epidemics clearly proved. It is, nevertheless, probable that the importance of water as a means of transmission has been overrated in both instances; for the organisms are often destroyed in time by natural factors constantly at work in most waters. These factors are: first, the small amount in many waters of sufficient organic matter to serve as food for the bacteria; second, the action of sunlight; and third, the antagonistic effect of many harmless microorganisms indigenous in many waters. There is little reason to believe that pathogenic organisms usually multiply to any degree after gaining entrance to most of the potable waters, but it is possible that water may be consumed at such an early period after its contamination that the infectious agents have not yet been killed. They may be carried by water through the earth for a considerable distance, although the natural filtering properties of soil tend to reduce the number of bacteria so carried. As is well known, the deposition of *fecal matter* in close proximity to sources of water-supply may be the means of infection, as was strikingly shown in the typhoid epidemic at Plymouth, Pa., in 1885.

Drinking water may be contaminated from *urine* alone, as was apparently shown by Kubler and Neufeld, who isolated typhoid organisms from a well of water that had caused a small outbreak of typhoid fever. The urine of a typhoid patient had been emptied near the well, and as no colon bacilli were found in the water, it seemed probable that the contamination was not of fecal origin.

Infection Through Water in Bathing and in Washing Clothes or Utensils.

In *bathing* water may enter the various openings of the body. As public baths are often frequented by large numbers of people suffering from various diseases, infection is quite possible, especially if the water be infrequently changed. The affections likely to be transmitted are the various forms of acute inflammations of mucous membranes, as *conjunctivitis, rhinitis, pharyngitis* and *laryngitis*. There is little positive evidence that venereal disease may be conveyed in this manner. Impure water used for the purpose of bathing may also bring in contact with the skin microorganisms that penetrate it and thus find their way into the blood and deeper tissues. While this occurrence may be rare, its reality is suggested by the experience of A. Looss, at Cairo, who observed that when he allowed water containing the embryos of *Uncinaria duodenalis* to dry upon the skin of his hands, an itching sensation occurred at the point of contact, and apparently as a result, he became infected with parasites whose eggs he subsequently discovered in his stools. He was able later to make an actual demonstration of the penetration of the skin of a cadaver by the larvæ of these parasites, and concludes that this is the usual method by which they enter the human body. *Washerwomen* are exposed to various infections in the process of rubbing infectious clothes, for foamy particles are thrown into the air, and frequently alight on the face, in the nostrils or mouth. If the microorganisms have sufficient virulence, and have not been destroyed by the action of the heat of the water or the soap, infection may occur. Occasionally infections of *diphtheria, scarlet fever* and *typhoid fever* seem to have occurred in this way.

Infected water is frequently used to *wash utensils*, and in this way milk, uncooked vegetables, and other foods may be contaminated. Milk is an excellent culture-medium for most pathogenic organisms, and epidemics may be due to contamination occurring in this way.

Infection Through Water Introduced Within the Tissues.

Virulent pus-producing organisms are rarely numerous in the general water supply, and thus operative infections are due chiefly to infected utensils, hands, or other materials. In certain German cities, although the number of saprophytic organisms in the water is quite large, it has been found safe to use water from the general water supply for operative purposes without sterilization; but as there seems always to be a possibility of infection occurring through this medium, few surgeons are willing to take the risk of using unsterilized water. Muddy water may contain certain of the virulent organisms found in earth, such as the *tetanus bacillus* and the bacillus of *malignant edema,* and Hirst has reported cases of puerperal tetanus in which infection seemed to result from intrauterine douches of such water, to which creolin, an unreliable germicide, has been added.

SOIL.

The soil serves as one of the great laboratories of Nature. Here organic matter is reduced to simple inorganic compounds that by a union with the elements, oxygen and nitrogen, are changed into more elaborate compounds, serving as food for plants. In the soil water is impregnated with soluble mineral constituents, with gases and at times with organisms capable of exciting disease. From the soil gases and aqueous vapor are given off to the surrounding air, while temperature variations in the adjacent air are modified. Important factors are the porosity, the ground water level and the amount of organic decomposition occurring in the soil. Very damp soils, those with a constant high ground water level, those that are relatively impervious and those containing large amounts of decomposing organic matter are unhealthful.

Infection from soil has been attributed (1) to *gaseous* or *miasmic emanations,* (2) to the *ground* or *soil air,* (3) to the ground water, and (4) to *materies morbi* contained within the soil itself.

Ground Air.

Ground air, or the gas contained within the interstices of the soil, is usually richer in carbon dioxid than ordinary air, and may also contain ammonia, ammonium sulphid, hydrogen sulphid, and other gases derived from the decomposition of animal or vegetable substances. Its humidity is usually high. That gaseous emanations from soil contain infectious principles is an ancient supposition that has not been confirmed by exact investigations. Although the ascent into houses of ground air with its excessive humidity, small percentage of oxygen, and excess of gases arising from organic decomposition may be undesirable, may render them damp, unwholesome and favor the multiplication of molds and bacteria, it cannot be directly credited with producing specific diseases. Care should be taken that the ground air about dwellings is not contaminated from leaky drains and cess-pools, or from decomposing organized matter; not because these contaminations directly produce disease, but because such unwholesome surroundings tend to depress the normal immunity of the body and to favor bacterial invasion.

Ground Water.

Soils vary in their capacity for absorbing and retaining moisture; humus having marked retaining power, and chalk, loose sand and gravel having much less. Much depends, however, upon the permeability of the subsoil, the declivity, and the protection afforded by surface vegetation. Not only is the soil kept moist through rains, but by capillary attraction water is constantly rising from subterranean sources. The subsoil water is subject to movements that occur at different depths in various soils, varying from two feet to several hundred feet from the surface. Pettenkofer and his pupils have affirmed the close relationship of soil water with such diseases as *cholera* and *typhoid fever*, but the claim that there is a constant and direct relation between the condition of the soil and the occurrence of epidemics is obviously erroneous. The danger from soil water lies in its ability to transmit pathogenic bacteria to soils and sources of water supply, and to maintain an unwholesome dampness in houses. The soil, however, acts as a bacterial filter, reducing the number of bacteria that pass through it for long distances, so that the possibilities for a wide dissemination of disease, except through subterranean streams, by ground water are too slight to be considered. Through short distances, as a few feet, or possibly a few yards of space, bacterial conveyance may occur, and Dempster has shown that cholera spirilla may be carried through two and a half feet of porous soil by currents of water. Fortunately, many pathogenic bacteria are unable to live for long periods of time in soil. An indirect relation between soil water and certain diseases does, however, occur. Malaria is associated with marshy soils, because they are suitable for the propagation of mosquitoes. *Chronic rheumatism* is known to be favored by dampness of the soil, probably merely because it renders the atmosphere cold; although the probability of infectious agents being demonstrated for the so-called rheumatic affections must not be overlooked. A few diseases like *goiter, calculus* and *myxedema* have been attributed to certain mineral constituents entering drinking water from the soil; but the relationship is too inconstant and variable to warrant the conclusion. Haviland, especially, has studied the geographic distribution of *cancer,* and believes the affection to be much less frequent in elevated places and districts of limestone formation, and most frequent in floody, low-lying clayey areas. Assuming that carcinoma is due to a parasite, he suggests that the moist soils, especially of alluvial earth, favor the development of microorganisms. Cancer, however, is known to prevail upon elevated and dry lands; and when d'Arcy Powers sowed land, apparently complying with the requirements of Haviland, with bits of carcinomatous tissue, the results were negative in the exposed animals. Epidemics of *diarrhea* have been attributed to the moisture, heat, or uncleanness of soils. Ballane says that excessive wetness or complete dryness are unfavorable to the prevalence of diarrhea. As asserted years ago by Bowditch, the development of pulmonary phthisis is favored by low-lying, damp soils, which are found also to predispose to colds and catarrhs of the respiratory tract.

Bacterial Contamination of Soil.

In portions of the New Hebrides the soil is so rich in the bacilli of *tetanus* and *malignant edema* that the natives employ it as an arrow poison. Garden earth is known to contain these organisms frequently, not, however, in large numbers, as a rule, nor do the organisms appear to undergo any considerable multiplication in the soil. When, under certain conditions, portions of such infected soil enter deep or punctured wounds, tetanus results. Nearly all other pathogenic organisms rapidly die in ordinary soil, especially if it be dry. In *damp soils* the organisms of *cholera, typhoid fever* and *plague* may live a number of weeks or months. In the damp dirt floors of Chinese and Japanese dwellings that are protected from the action of the sunlight, the bacilli of plague have been found months after the disease has occurred in the house. Rats and other vermin may acquire infection from such contaminated soil and may then transmit the disease to the human family.

Infection from the Buried Animal Body.

Pasteur believed that earth worms conveyed the bacillus of *anthrax* from the buried animal body to the surface and led to the infection of grazing cattle, but later experiments tend to disprove this supposition.

Although the chemical study of the *water* yielded by wells and springs in the neighborhood of cemeteries has shown that such water may contain abundant dead organic material in solution, bacteriologic investigations have failed to bring forward conclusive evidence that pathogenic organisms are transmitted from buried bodies through the ground water, to distant sources of water-supply. Experiments in this respect have been conducted by Klein, Petri, Yokote, and others. Klein found that disintegration of the animal body after burial is chiefly brought about by an anaerobic bacterium that he terms the

Bacillus cadaveris saprogenes. The pathogenic bacteria seem to play but a small part in the dissolution process and are soon destroyed. Experimenting with the bodies of guinea-pigs infected by various pathogenic organisms, it was found that none of the latter were capable of maintaining vitality for more than a few weeks after burial. No matter whether the body was incased in a coffin, or wrapped in a piece of fabric, or buried directly in the earth or in sand. The soil adjacent to the buried body was free from pathogenic bacteria. It is inferred that the vitality and infectiousness of pathogenic organisms contained in the viscera disappear long before the outer skin has become permeable to them. Yokote using the bodies of mice killed by plague obtained similar results.

Koch has shown that the bacillus of anthrax and other pathogenic bacteria can be grown in sterilized but not in unsterilized soil. Wilson has examined graveyard soils and bits of old coffins without finding pathogenic organisms. The rapidity of the destructive action of soil upon bacteria varies decidedly, peat being especially rapid in its action, and is to be attributed to the character and number of the contained saprophytic microorganisms.

There is, therefore, no bacteriologic evidence that properly placed and conducted cemeteries are a menace to the adjacent neighborhood. It is conceivable, however, that infection might follow interment with access to subterranean streams. Interment should only be made in porous soils that have a low ground water level, and to facilitate rapid decomposition impervious caskets or graves lined by masonry should be avoided.

CLIMATE AND SEASON.

The principal features that produce and modify the climate of a place are its latitude, altitude, proximity to bodies of water, and the prevalent winds and rains. Besides this, climate may be modified by the topography of the land and the character of the soil. The human body has a remarkable ability to adapt itself to different climates, and with proper food, clothing, exercise, and the avoidance of the parasitic causes of disease, the climate has a minor effect upon the health, except in cases of the weakly or diseased. It is customary to classify climates into *warm,* including the *equatorial, tropic* and *subtropic; temperate,* with a mean temperature of 60° F.; and *cold;* also into *plain, mountain* and *marine* climates.

Climate is not an exciting cause of disease, yet by its favoring or inhibiting influence upon the determining factors it may play a somewhat important part in disease production or prevention. Thus, warm, moist climates are favorable to the growth of parasites, and the parasitic diseases are especially common in the tropics. Gastrointestinal disturbances, cholera, yellow fever, and malaria are also prevalent, measles and scarlet fever comparatively rare, in hot climates. Pulmonary tuberculosis is observed more frequently in moist than in dry regions, at the sea-level than at altitudes; while rheumatism, gout and pneumonia are more frequent in cold, damp climates. Marine climates predispose to rheumatism and pulmonary affections and aggravate existing neuralgias. When we except certain affections like heat-stroke and frost-bite, it will be evident that climate does not act except as a predisposing cause of disease, and with a better understanding of the parasitic nature of disease, the importance of climate as a causal factor has greatly depreciated.

The slight influence of climate on the development of disease is well illustrated in the recent experiments as to the production of malaria upon the Roman Campagna. In a place noted for its unwholesome, malarious climate, a number of observers lived in perfect health for months, merely by taking precautions to avoid mosquito bites. As a therapeutic agent, however, climate is often of great value.

Vegetation.—The presence of many trees in a district has an important regulating effect upon the climate. By their presence the winds are modified, the temperature is made more equable, the air is rendered more uniformly humid, there is a diminution of dust, while certain gases believed to be healthful may be given off by the trees. The danger from foods is much less in woody districts, as the trees serve to regulate the penetration of water into the soil.

SEASON.

Variations in temperature and humidity accompanying changes in season are associated with variations in the incidence of certain diseases that are analogous to the incidence of the diseases in relation to climate. During the summer months gastro-intestinal maladies are prevalent and the tropic diseases make the greatest incursions into the temperate zones.

This is usually due to the fact that all causal conditions are favorable only during these months. Thus, yellow fever is confined to the warm months in temperate climates, for the reason that the contanimating mosquito is active only in warm weather. Probably for a similar reason cholera occurs chiefly in the months of August, September and October. The prevalence of the gastro-intestinal disorders of childhood, such as cholera morbus, cholera infantum and other forms of enterocolitis, is greatest during July and August, a period in which it is most difficult to properly preserve foods used for infant feeding. During the cold, damp months catarrhal affections, pneumonia, rheumatism and gout are most frequent. This is explained not only by the increased exposure and chilling of the body, but also by the less hygienic method of living, persons being disposed to spend more of their time in overheated and poorly ventilated rooms and to indulge more in overeating and overdrinking than during other seasons of the year. The acute exanthemata are more prevalent during the autumn and winter, the propagation of the infection being favored at this time by the tendency of people to collect in schools and halls. Typhoid fever and malaria are more widespread during August, September and October than in other months. This is probably due to the activity of the insects transmitting these diseases during the late summer. The fall rains may aid by sweeping infectious material into the wells and streams from which drinking water is taken. Diphtheria, measles, scarlatina and smallpox are most prevalent during the cold months. This may be due to the greater facilities for infection during the winter time afforded by crowded and poorly ventilated cars, houses or public meeting-places. We have no good reason for assuming that season alone is the direct causal agent in facilitating the propagation or invasion of the exciting agent.

Excessive dryness or moisture may increase the morbidity during any season. This is apparently well shown in relation to autumnal diarrheas in the following table:

RELATION OF AUTUMNAL DIARRHEA TO RAINFALL.—(Hope.)

	Average Rainfall June to September.	Annual Average of Deaths from Diarrhea in the Third Quarter of the Year.
Average of 6 wet summers..	13.8	373
Average of 14 dry summers..	10.9	573
Extreme wet summer, 1891..	16.0	203
Extreme dry summer, 1895..	7.7	819

CHAPTER V.

THE EXTRINSIC FACTORS OF DISEASE. PHYSICAL—TOXIC.

TOXIC FACTORS IN DISEASE.

Poisons are substances that in small amounts interfere with the functional and structural integrity of the organism. They may be *ectogenous*, or arise without the body, or they may be formed, as are leucomains, within the body, and therefore be *endogenous*. Endogenous poison result from the immediate or remote action of an exogenous cause. Thus, a substance may be toxic because when introduced into the body it liberates endogenous poisons from the cells. Poisons may show their predominant action locally upon the tissues with which they first come in contact; or in passing through the body they may cause marked degenerative changes in the parenchyma of organs; or they may alter the character of the blood, or show their chief action upon the nervous system. As a general rule, the most marked lesions are found at points of entrance and exit from the body—where the greatest concentration usually occurs—or in cells especially vulnerable, as those of the central nervous system.

Local Poisons.—The chief inorganic local poisons are the caustic acids, alkalis, and certain salts of the heavy metals, especially of mercury, zinc, silver and antimony. These produce marked chemical changes in the tissues, leading to their death, with protoplasmic coagulation or solution. There are also certain *vegetable* and *animal* products that produce marked toxic action when locally applied. Croton oil produces an erythema followed by vesiculation and pustulation, and poison ivy and poison oak, in suceptible individuals, cause marked hyperemia and the formation of large bullæ. Pfaff found in both *Rhus toxicodendron* and *Rhus venenata* an oil he termed *toxicodendrol*, the application of 0.001 milligram of which, dissolved and mixed with two drops of olive oil, gave rise to intense local irritation in a susceptible subject. In the lower animals these drugs produce generalized fatty degeneration. Many animals elaborate poisons having a local as well as a general action. The venom of serpents and lizards (Gila monster), the cutaneous secretion of toads and salamanders, the poison of arachnids, myriapods and insects, the salivary secretion of mosquitoes and cantharidin derived from certain beetles are example of these toxic substances.

Parenchyma Poisons.—Many poisons having a marked local action, such as the mineral acids and alkalis, are practically harmless when diluted. Their effects, therefore, are only found locally. Other substances as phosphorous, arsenic, antimony, mercury and many of the animal and vegetable poisons, not only produce local lesions, but when absorbed even in dilution cause a high-grade parenchymatous, fatty or other degenerative change, especially in the liver, kidneys, heart, blood-vessels and muscles. With these drugs it becomes important not only to control the local effects, but also to prevent their absorption. Protoplasmic metabolism or muscular contractility may be stimulated, depressed, or abolished. Other poisons, as alcohol and lead, as well as those present in the body in syphilis and of gout, stimulate the interstitial tissues to harmful overgrowth, thus causing the various *cirrhoses* or *scleroses.*

Blood Poisons.—These act by (1) forming more stable combinations with the hemoglobin, thereby preventing the ordinary oxygen-carrying function of the blood, (2) by causing a solution of the corpuscles, and (3) by inducing changes in the plasma, interfering with its coagulation.

The combination most frequently formed with the hemoglobin is called *methemoglobin.* It is isomeric with the normal oxyhemoglobin, but is so stable that the oxygen is not liberated for the use of the tissues. It gives the blood a sepia-brown color. The formation of methemoglobin is often accompanied by the solution of the corpuscles (hemolysis). This change is produced by many of the newer coal-tar remedies, such as acetanilid, phenacetin, trional, and also by chloral, chloroform, amyl nitrite, etc., potassium chlorate, pyrogallol, dinitrobenzene, nitroglycerin. The inhalation of carbon monoxid even in so small a proportion as 0.02 per cent. is injurious. *Cyanhemoglobin* results from the toxic action of hydrocyanic acid, and it gives the blood a bright red color. From the inhalation of hydrogen sulphid, *sulphur-methemoglobin* may be formed. Hydrogen arsenid, potassium chlorate, serpents' venom, phallin from poisonous mushrooms, other poisons and the various hemolysins have a marked solvent action upon the corpuscles.

Many poisons, including ricin, abrin, alcohol, ether, and the blood serum from a different species of animal, will coagulate the blood.

It is rare that a poison acts solely upon the blood. Usually there is also an injurious action upon visceral protoplasm, especially that of the central nervous system.

Nerve Poisons.—These may have a predominant action upon the cerebral cortex, the basal ganglia and spinal centres, or the peripheral nerves. Certain poisons, as chloroform, ether, chloral, coniin, diphtheria toxin, and the bromids, chiefly depress, while others, as strychnin, tetanus toxin, caffein, cocain, chiefly stimulate nervous excitability. The toxic substance may show a selective action upon certain centers, nerves, or ganglia, as is exemplified in the depression of the motor centers of the cord by physostigm, and the stimulation of the vagi by digitalis.

Prophylaxis.—Against the mineral poisons we have a series of chemical antidotes, against those of vegetable origin a limited number of imperfect physiologic antidotes, while against many of the venoms and bacterial toxins, efficient antisera have been developed. Obviously, it is of first importance that the poison be prevented from entering the body, and second, that should it enter, the appropriate antidote be administered before serious cellular changes have occurred.

VENOMS.

Certain animals, as the *Gila monster* of Texas and Central America, secrete a poisonous saliva. Bites of the *salamander, toad* and *triton* and the bites or stings of certain *fish* are followed by phlegmonous and gangrenous inflammations. Many of the *spiders* inflict bites that are poisonous, the bite of the tarantula of tropic countries being especially serious. Of the *myriapods,* the centipede and scorpion cause painful and at times serious bites. The effects of the stings of insects are well known.

In a number of recorded instances the sting of a single bee, hornet, or wasp has resulted in death. Less serious are the bites of certain other insects, as mosquitoes, flies, bedbugs, fleas and ants.

The most important venoms are those secreted by the snakes. All snakes possess poison glands, but in the majority these are rudimentary or are without outlet. In North America there are but four *venomous snakes.* Three of these, the *rattlesnake* (genus *Crotalus* and *Sistrurus*), the *copperhead* (*Ancistrodon contortrix*), the water moccasin or "*cotton mouth*" (*Ancistrodon piscivoris*), distinguished by a deep depression between the mouth and eye, belong to the pit vipers family, Crotalidæ. The *coral snakes* belong to the family Elapidæ. They are very venomous, although usually described as amiable in disposition. The rattlesnake rarely bites except under provocation, but the copperhead and the moccasin are more aggressive. Other venomous serpents are the *cobra* (*Naji naja*), chiefly found in India, the most venomous of serpents; the deadly West Indian "fer de lance" (*Bothrops lanceolatus*); the *vipers* of Europe, the bites from which rarely cause death in adults; the Egyptian asp (*Naja haje*) and the *Cerastes* (*Vipera hasselquisti*), reputed cause of Cleopatra's death. In India about 20,000 people die annually from snake bites, chiefly from that of the cobra. Snake venoms have been studied by Weir Mitchell and Reichert, Calmette, Phisalix and Bertrand, Fraser and others. They contain toxic globulins, albumoses, and peptones—compounds that may produce marked local lesions, characterized by great edema, and at times gangrene, serious blood changes, and profound depression of the nervous centers, leading to convulsions or paralysis. Death usually results from progressive respiratory failure. If recovery takes place, the cicatrix may in certain cases annually become painful and ulcerate.

The results of snake bite vary with the species of snake, the amount of venom injected, the situation of the bite, and the size and general resistance of the person bitten. Thus, the bite of a cobra, into a vein or artery, has been followed by death in two minutes, and in general about 40 per cent. of all cobra bites are fatal. About 6 per cent. of rattlesnake bites are fatal, Mitchell and Reichert mentioning one case of death within 40 minutes. The harlequin or other variety of the coral snakes rarely bites, but ensuing unconsciousness and death have been recorded in a few instances. Moccasin bites are occasionally fatal, the bite of the copperhead rarely so. It is unusual for the bite of the viper to be lethal except in the case of the feeble or in children. Most dangerous are bites in the very vascular portions of the body, especially by snakes of large size, that are fasting and have not recently discharged their venom, less serious are bites into adipose tissue.

Prophylaxis.—The effects of snake bite should be combated: (1) by localizing the poisons by tying a tight band around the limb above the bite and removing as much of the poison as possible by incision or excision and suction; (2) the poison bites, according to Calmette, should be treated by hypodermic injections of substances that locally neutralize the venom, as calcium and sodium hydrochloride, gold chlorid, or potassium permanganate; (3) most efficient is the use of *antivenene,* the value of which has been worked out by Fraser, Phisalix, Bertrand and Calmette. This antidotal serum is obtained from horses that have been immunized by progressively increasing doses of venom. Antivenene of one snake-venom is also efficient against other forms; that prepared from the rattlesnake protecting against the cobra, and vice versa, as shown by McFarland. Antivenene is a perfect antidote, provided it can be injected before serious injury has been done to the central nervous system. If, in biting, the hollow fang of the serpent penetrates a blood-vessel so that the venom is thrown directly into the circulating blood, death may occur before the antidote can be introduced. As a rule, however, as has been shown in the French troops of Madagascar, injection of antivenene made within one-half hour of the bite of the more venomous serpents is usually efficient. Venoms are not injurious when swallowed unless they come in contact with broken mucous membranes. They are usually destroyed by high temperatures. Owing to its depressing effect upon the respiration, alcohol is contraindicated. In certain reported cases its use may have determined the fatal issue. Respiratory stimulants such as strychnine, atropine and caffeine may be judiciously administered.

Food Poisoning.

Besides the injurious effects resulting from its excess or deficiency, food may possess unwholesome qualities from improper selection, age, growth, season or environment, from disease, from decomposition, and from contamination with vegetable and animal parasites.

Animal Foods.—The meat of embryo calves and of pregnant animals is considered unfit for food. The flesh of animals that are fed upon certain substances may be toxic, as is that of birds that have eaten mountain laurel. Season may affect the wholesomeness of animal foods; for instance, the flesh of certain fish is toxic in the spawning period. Fish or shellfish may acquire toxic substances through living in certain waters. Schmitmann found that oysters placed in the water of the harbor at Wilhelmshaven soon became poisonous, while the poisonous bivalves from this bay lost their toxic properties when placed in the open sea. As Lindener found that the filtered water from this bay did not render the oysters toxic, it would seem that the process was one of infection rather than impregnation by a poisonous substance. These oysters produce disease characterized by paralytic symptoms, and from them Brieger has isolated a ptomain that he calls *mytilotoxin.* Animals are subject to a number of diseases that may be transferred to man in food, including *tuberculosis*, *helminthiasis* and *anthrax.* The danger of contracting parasitic diseases is obviated by thorough cooking and careful meat inspection. The flesh from animals affected with tuberculosis, anthrax, glanders, actinomycosis, hog cholera, or with *animal parasites* should never be used for human consumption, no matter how localized the lesion.

Decomposition of food may result in the formation of toxic ptomains, such as the *tyrotoxicon* of milk and cheese. *Botulismus* (*allantiasis* or *sausage poisoning*) may be acquired from improperly preserved sausage, bacon, chicken, ham and other meats. Ermengen has isolated from toxic meat and from the spleen of a person dead of the disease an anaerobic bacillus, the *Bacillus botulinus,* that elaborates a powerful toxin.

Other outbreaks of disease characterized by vomiting, diarrhea and collapse, and attributable to the ingestion of meat are apparently due to the *Bacillus enteritidos* of Gartner—an organism resembling those of the colon group.

Vegetable Foods.—Abnormal methods of growth may cause the production of injurious combinations in the metabolism of plants. Vegetables or fruits raised out of season or by unnatural forcing processes are usually less nutritious and more apt to cause gastro-intestinal disturbances than those grown under normal conditions. Food-plants are sometimes attacked by certain fungi, as the *ergot* of *rye* (spurred rye) and *blight of corn.* Grave pathologic changes may follow the ingestion of such diseased cereals. Food inspection and the penalizing of traffiic in unwholesome food will limit their injurious effects.

Ptomains.

In the bacterial decomposition of animal or vegetable proteids, crystallizable basic compounds resembling the alkaloids are produced, that are termed ptomains. A few of these are distinctly toxic, while many are not poisonous. Their properties seem to depend in part upon the micro-organism and in part upon the nature of the proteid decomposed. Thus, neurin is produced by putrefaction from meat; ethylendiamin, from the flesh of fish; mytilotoxin, from poisonous mussels; tyrotoxicon, from ice cream, milk and cheese, while cedavarin and putrescin may be developed in the putrefaction of the flesh of both mammals and fish. Muscarin is the active principle of poisonous mushrooms, but also develops in decomposing human viscera and fish. The rule has been formulated that the toxicity of putrefactive products is in direct ratio with the complexity of the substance involved. Thus, those produced in the decomposition of vegetables are apt to be much less toxic than those found in the putrefaction of flesh.

It is noteworthy that in most of the instances of ptomain poisoning cited, the food responsible, while perhaps changed in character, was not clearly putrid. Moreover, the use of gamy flesh by epicures, of rotting meat by savages and the lower animals does not seem to produce disease poisoning. It is probable that many so-called cases of ptomain poisoning are, in reality, the result of true infections or result from the ingestion of bacterial toxins. In any case the recorded instances of poisoning from oysters, fish, veal, beef, pork, milk and other foods, used either raw, cooked, canned or pickled emphasize the necessity for great care in the selection and preservation of food. As some of these poisons withstand high temperatures, cooking is an uncertain safeguard.

CHAPTER VI.

EXTRINSIC FACTORS OF DISEASE.

SOCIOLOGIC.

Food Preservatives.

Within recent years there has been an increasing tendency to resort to such chemicals as salicylic, benzoic or boric acids; borax, sodium sulphite and bisulphite and formaldehyde to preserve or improve the appearance of meats, milk, butter and vegetables. All of these substances have shown a more or less injurious action upon the body, inhibiting digestive processes or directly injuring the blood or tissues. Edibles canned in tin may contain tin salts, or, what is more serious, traces of lead from the solder used. Unless a good solvent for lead be present, the amount contained by the food will not be sufficient to be harmful. When the tin consists of an alloy of lead and tin (terneplate) or when food is wrapped in lead foil or kept in pewter receptacles, an injurious lead contamination may occur. The use of chemical preservatives in food is to be prevented by stringent legal enactment.

Density of Population.

The crowding together of large numbers of people in limited areas is usually a result of poverty, and, as a rule, indicates that the individuals involved are less capable of successful existence than those living in more commodious quarters. It, therefore, follows that crowded areas usually show a high proportion of persons with deficient resistance, of unclean habits, with insufficient or improper nourishment, undesirable occupations and a general lack of care in guarding their bodies against unfavorable influences. Such associations conduce to defective ventilation, improper food, and unhygienic surroundings, and, of course, strongly tend to the development of deficient stamina, and the propagation of various diseases that are likely to spread to those in better circumstances. As expressed by Cohen, "The miseries of Lazarus are visited upon the children of Dives." It is, therefore, not strange that overcrowding is associated with increased rates of morbidity and mortality.

The *diseases* especially prevalent in areas of dense population are *tuberculosis,* the *acute exanthemata,* and the gastro-intestinal disorders of childhood. It is evident that overpopulation is not of itself the cause of the prevalence of these disorders, but rather that they result from the unhygienic conditions that are usually associated therewith. For this reason there are occasional marked exceptions to the rule that overcrowding is associated with a high mortality.

Not alone are diseases spread by over population but vicious and immoral habits are propagated and tend to injure the entire community.

With especial force do these pernicious influences affect children exposed to slum or tenement life. From its influence, therefore, upon the physical and moral health alone, such overcrowding should not be permitted. No city can afford to foster mental and physical degradation by permitting slum life. Tenement life is permissible only under such model conditions as have recently been introduced in a few of the larger American cities. Sunlight, fresh air and play grounds must be supplied, dwellings must be of approved construction and the segregation of the vicious and immoral from the upright poor maintained if our civilization is to persist. In asylums, hospitals, dormitories and especially in the massing of large bodies of soldiers in barracks or on the field the evil effects of overcrowding are too apparent and are to be combated by recourse to the approved rules of civic and military hygiene, embracing care as to dirt, ventilation, exercise, cleanliness and moral oversight.

Dissipation.

Health is maintained without effort only when there is a proper regulation of the food-supply and an absence of abnormal stimulation or sedation of function. Gluttony, sexual erethism, or the abuse of stimulants and narcotics, is a constant menace to the health equilibrium. Not only do such excesses lead frequently to functional and structural abnormalities, but they also tend to increase susceptibility to various pathologic processes. Animals exposed to excesses in physical exercises more readily contract infectious diseases, and the administration of alcoholic beverages may also alter their natural immunity. Abbott's observations of rabbits, and especially the elaborate experiments of Dr. Taavlaitmen, apparently show that in dogs, rabbits, guinea-pigs, fowls and pigeons, alcohol distinctly increases the susceptibility to experimental infection. This diminished resistance results, no matter whether the alcohol is given before, during or after the time of inoculation, or administered by the mouth or under the skin. Careful control experiments showed that no temperature changes resulted in the animals, except a reduction after excessive doses of alcohol. In the infected animals, that are given alcohol, the abnormal temperature of experimental disease persists longer than in infected animals that do not receive the drug.

The experimental evidence that alcohol increases the susceptibility to infection is strongly corroborated by clinical observation. Of 2192 persons with tuberculosis studied by Lancereaux over one-half were confirmed drinkers. The habitual use of essences, including absinthe and the like, seemed especially to predispose to phthisis. Pneumonia, tuberculosis, enteric fever and other infections usually run a more severe course in alcoholics, and the frequency with which in the dissipated relatively slight injuries develop grave local and general septic manifestations has been repeatedly noted by surgeons. Not only is there a condition of depraved tissue nutrition in those who use alcohol to excess, but the power of assimilation of food is much reduced.

Moreover, alcohol is *directly toxic*. The ingestion of from 500 to 1000 c.c. of whiskey (from one to two pints) at one time by an adult has repeatedly resulted in death within a short time, while much smaller quantities have proved fatal in children.

Spirituous beverages may contain besides ethylic alcohol, more toxic substances, such as propylic, butylic and anylic alcohol, acetone and various aldehydes, ethers and essential oils. The bitters, cocktails, and other so-called mixed drinks may contain a number of these toxic substances. Absinthe is said to contain nine toxic essences. Certain artificial flavors are poisonous or may accidentally be contaminated. Malt liquors are also subject to intentional and accidental adulteration with poisonous substances. Thus, *Cocculus indicus* has been used to fortify beer, and the widespread epidemic of arsenic poisoning in Birmingham during 1900 and 1901 was traced to beer containing glucose manufactured with sulphuric acid contaminated by that metal. Lead poisoning has also been ascribed to the use of beer contaminated by vessels and pipes.

Prolonged tippling results in a complex series of disturbances, dependent upon the character of the tipple, and the habits and idiosyncrasy of the person. Overindulgence in malt liquors is particularly apt to be followed by parenchymatous and fatty degenerations in the viscera; while distilled liquors most frequently lead to gastro-intestinal disorders, forms of sclerosis affecting especially the liver, kidneys, and central nervous system, neuritis and palsies, obscure neuroses, epilepsy, mania and dementia. Alcohol seems to increase the tendency to rheumatism and gout. There is a noteworthy relationship between the incidence of alcoholism, the psychoses, insanity, venery, and crime. In part, this is due to the favoring influence of alcoholism upon the spread of other forms of dissipation and venereal disease. Alcohol increases sexual desire, obtunds the moral sense, and favors a careless disregard of precaution against infection. Forel found that venereal infection was more frequent in conjunction with occasional than habitual alcoholic indulgence. In over three-fourths of the cases studied, the patients were under the influence of alcohol when infection occurred. Dana places the average duration of life of the continuous drinker at 15 years and of periodical inebriates at 19 years. As a rule the hard drinker becomes a wreck about the age of 40.

In portions of Ireland *ether* is a preferred tipple. In Philadelphia the theft of *gasoline* from street lamps led to the discovery that this was inhaled by children for the purpose of inducing intoxication. The physical and moral impoverishment resulting from the *chloral, opium, cocain, cannabis, indica, caffein, chloroform* and *ether* habits is well known. The excessive use of *tobacco* may cause disease of the heart, impairment of vision, and nervous irritability or exhaustion. The tendency of those suffering from forms of chronic intoxication to become sterile or to have neurotic progeny or morally or physically defective, may again be mentioned.

Sexual excesses lead directly to diseases of the nervous and circulatory systems, as well as directly to venereal and other infections and to their grave sequels.

Occupational spasms, palsies, or neuroses result from physical and mental *overwork,* or may be hereditary expressions of ancestral dissipation.

Certain psychic or intrinsic conditions, such as *inordinate ambition,* depraved or perverted *emotions,* as well as depressing and exhausting *habits,* and the like, may be mentioned under this head, as they involve excessive expenditure of energy.

In the *prevention* of dissipation especial stress should be placed upon the moral education and the development of self-control. This is the more necessary in the case of those inheriting morbid tendencies to depraving indulgence. Such persons should be made to realize that the expression of hereditary tendencies is by no means inevitable, and that self-restraint may be cultivated. As against sexual impurity it is of especial importance that a higher moral standard be cultivated among men. Gower's dictum that "No man was ever worse for continence or better for incontinence" should early be impressed upon the minds of youth. Moreover, the fact that venereal disease is an almost inevitable concomitant of unchastity should be widely taught. Sexual hygiene properly finds a place in the public school curriculum. The family physician may do much by maintaining an advisory oversight of those with a tendency to mental or nervous affections, pointing out the character of work to be adopted and insisting upon appropriate exercise, relaxation and nutrition.

OCCUPATION.

The influence of occupation upon disease production is due chiefly to unhygienic environment. Although some occupation are injurious from the overuse of certain functions, and others from the mental stress or the emotional excitement involved, and still others from too long hours of work, injury more often comes through the inhalation of vitiated, irritating, toxic or even infectious atmospheres, from exposure to trauma, to extremes or variations of temperature, to alterations in the atmospheric pressure, to the action of cathode rays and other forms of radiant energy, or to conditions causing deficient nutrition. Besides these factors, there is a tendency to dissipation associated with many occupations, that distinctly increases the liability to disease.

The Mechanical Effects of Occupation.

For the maintenance of health it is essential that all portions of the body be exercised. We are not created to exercise one single function, but to obey the "law of variety in exercise." It, therefore, follows that occupations attended by the disproportionate use of a single part of the body tend to a local overdevelopment and favor deficiencies elsewhere. Longevity is associated with those professions giving the greatest amount of moderate general exercise to the entire organism; while the more highly specialized forms of occupation are usually attended with an increased mortality. Disease, either general or local, is followed by fatty degeneration, deficient development, and atrophy, and, if general, it is often associated with anemia. Excessive use, on the other hand, may be followed by the so-called *occupation neuroses,* in which there occurs either spasms or palsy of the affected muscles. Common examples of these neuroses are the forms of *writer's cramp, pianist's cramp, telegraphist's cramp, typist's cramp, compositor's cramp, milker's cramp, tailor's cramp* and *sawyer's cramp.* In all these diseases there is a spasm affecting particularly the flexors and abductors of the forearm and hand when they are brought into use. The condition is difficult to relieve, except by avoiding the exciting cause either by changing the occupation or by means of some mechanical aid that will give rest to the affected muscles. A similar condition of the lower extremity may occur in *sewing-machine operatives, organists, turners, treadlers, dancers* and *athletes.* More rarely, paralysis attacks the overused muscles, as occurs in *scrivener's palsy* and in *hammerman's palsy.* The occurrence of either of these conditions implies an abuse of the muscles involved, and their prophylaxis lies in the adoption of a less narrowly specialized occupation.

Examples of *defective development* as a result of certain pursuits are common, and may be so pronounced as to enable one to determine the occupation from the deformity present. The poorly developed and bowed legs of *cowboys, cavalry officers, jockeys* and *grooms,* associated with a tendency to "toe-in" in walking, are suggestive of long-continued horseback riding. *Tailors* may show a wasting of the thenar eminences of the palm, a result of their method of holding the cloth. A narrow, contracted pelvis is especially common in *shop-girls,* or in women who have spent much of their time during the developmental period in standing. Long-continued standing also favors the development of varicose veins and ulcers. Those whose occupation causes them to *bend over* much of the time, frequently suffer from engorgement of the abdominal viscera, with associated congestive troubles and headache, and usually have round shoulders and grades of vertebral curvature. Such deformities are found in *shoemakers, students, engravers, miners, laundresses, gardners,* and may be very appositely contrasted with the erect carriage of those who make it a practice to carry burdens upon the head. *Shoemakers* frequently also develop a depression of the thorax involving the lower portion of the sternum and the false ribs. *Blacksmiths, carpenters,* and others who use one hand very much more than the other usually show a lateral spinal curvature, a result of the constant pull from one side. Other occupational deformities are the flabby, puffing cheeks of *those who blow wind instruments,* the lateral inclination of the head of *violinists,* the exaggerated hands of the *pianists,* and the characteristic condition of the internal metatarsus, or so-called "onion," in *toe-dancers.*

Callosities show such a close relationship to the occupation that Vernois has considered them from a medico-legal standpoint, as an important means in the identification of persons. They are found upon the tips of the fingers of the left hand in *violin, guitar,* and *'cello players,* upon three fingers of *drummers,* and the entire internal hand of *laundresses;* upon the right hand of the palm and fingers of *shoemakers,* on the radial border of the index-fingers in *woodcarvers,* on the index-finger and palm of *compositors.* On the left hand, on the palm, index fingers, and thenar eminence in *locksmiths,* and over the five metatarsal bones externally in *tailors.* Callosities may also be present over the tuberosity of the tibia in *clergymen,* over the ensiform portion of the sternum in *wheelwrights,* over the ischial region in *horsemen,* and upon the entire surface of the left thigh in *shoemakers.*

Occupations may be associated with characteristic *traumatisms,* as is seen in the peculiarly pigmented hands and faces of *coalminers,* a result of the embedding of bits of coal beneath the skin. Cataract is especially common in *blacksmiths* apparently the result of the bright light and flying particles of metal to which they are exposed.

Forms of *hydrarthrosis* or distention of the synovial bursas are associated with certain occupations. The enlarged bursa under the elbow found in *miners* and in *draftsmen* (miner's elbow) and the distended prepatellar bursa in *scrub-women* (housemaid's knee) are examples of this affection.

Characteristic changes in physiognomy are impressed by many vocations. The color and texture of the skin, the degree of dilatation of the superficial vessels and the condition of the sebaceous glands are modified by climatic exposure, abstinence or excess and the general care of the person. The development of the face and presence of characteristic lines or wrinkles result from the predominant use of certain muscles.

Thus, the recurrent expression of certain emotions that is associated with particular callings leaves an indelible impress upon the face.

The *internal organs* are mechanically affected by certain occupations and modes of life. The atrophic groove found in the adipose tissue about the waist of *blacksmiths, butchers,* and others who wear cords tightly tied about the body, and the furrow in the livers of women that practice tight lacing, are the results of continuous external pressure. Persons engaged in occupations associated with the inhalations of large quantities of *dust* have a tendency to certain characteristics lung affections. The black, anthracite lungs of *coalminers,* associated with the tendency to pulmonary tuberculosis; and the predisposition to fibroid and tuberculous changes in the lungs of *grinders, polishers, stone-cutters,* and the like, are the results of the inhalation of large quantities of irritating dust. In these cases the predisposition to tuberculosis seems to be brought about chiefly by the continued mechanical irritation, and this is found to be especially marked when the dust, being hard and insoluble, remains as a continued source of irritation. The names *"coal-miner's phthisis," "grinder's consumption,"* and like terms express the relationships of the grit to the disease. The softer dust from the wood and textile fabrics is less harmful. By the adoption of measures that give relief from constrained positions to the workers, that provide proper food and air-supply, and by the employment of respirators and, especially, proper ventilating and exhaust appliances where dust is generated, many of these injurious effects of occupation may be avoided.

Intoxications Associated with Occupation.

Certain occupations involve the use of *toxic* *materials,* with which the workman is apt to be brought in more or less intimate contact. The lesions produced, of course, depend upon the nature of the poison. In *silver-miners, smelters, potters, lead-burners, file-makers,* workers in *white lead,* and painters, the characteristic palsies and intestinal symptoms of lead (*plumbism*), antimony and arsenic are common. Miscarriages, still-births and infantile convulsions occur in increased frequency in the families of lead-workers. In mining, the extraction of gold, in gilding, the manufacture of hats, and in certain of the arts the use of *mercury* leads to poisoning, characterized by anemia, gastro-intestinal irritation, inflammation and ulceration of the gums, loss of teeth and other symptoms. Workers in *copper* rarely suffer from subjective symptoms, but may have the hair, skin and mucous membranes tinged green by the presence of copper salts.

Brass workers may develop anemia, tachycardia, nausea, vomiting, pains of the throat and abdomen, succeeded by progressive emaciation, or a form of ague, "brass founder's ague." Murray attributes these symptoms to the absorption of copper. In *match factories* a necrosis of the jawbone due to phosphorus (*phossy jaw*) occurs.

In the manufacture of *potassium bichromate,* poisoning characterized by forms of eczema, headache, ulceration and perforation of the nasal septum among the employes is not uncommon.

To those who work in atmospheres exposed to *irritating fumes,* as from nitric and hydrochloric acid, chlorin and bromin, are prone to develop affections of the upper respiratory tract. The vapors of sulphuric acid, however, seem comparatively harmless, and, indeed, enjoy the repute of conducing to good health. Cooks and others from the prolonged inhalation of small amounts of carbonic oxide, and anæsthetists from the inhalation of ether and chloroform may develop anemia and mental disturbances.

The impure hydrogen used for inflating *balloons* often contains considerable quantities of arsenic that may induce serious poisoning in æronauts.

In the manufacture of *vanilla flavors* workers may develop skin eruptions, pruritus, and furunculosis, headache, nausea, vertigo, insomnia, muscular pains, and irritation of the bladder. This is attributed to molds found upon the vanilla, or to cardol present in the oil of the cashew-nut that is used to improve the appearance of the vanilla bean. From handling candies, *confectioner's disease,* characterized by roughening and blackening of the nails and loosening of the periungual border occurs.

The use of potassium cyanid in certain *photographic* processes occasionally leads to poisoning.

Physicians and their patients have experienced toxic effects from the use of chemical *antiseptics,* including mercuric chlorid, carbolic acid, formaldehyde, iodoform, bismuth subnitrate, acetanilid and boric acid.

The substitution of aseptic for antiseptic surgery obviates the danger to the patient, and the surgeon who uses toxic solutions may increase his personal safety by wearing, during the course of operations or dressings, sterile rubber gloves over his previously sterilized hands.

The relatively high *mortality* associated with certain occupations is often traceable to an associated toxic influence. The following table indicates that renal and urinary diseases and gout are closely related to lead-poisoning and alcoholism, and that they frequently express occupational intoxications.

RELATIVE MORTALITY OF GOUT, RENAL DISEASE URINARY DISEASE AND LEAD-POISONING IN RELATION TO OCCUPATION.—(After Poole)

	Gout	Renal Disease	Urinary Disease	Plumbism
Lead-workers	0	85	76	2-11
Plumbers and painters	10	63	0	10
File-makers	0	82	0	75
Farm laborers	0	12	0	0
Potters (earthenware)	0	0	0	17
Glass-makers	0	0	0	14
Law clerks	8	56	35	0
Physicians	8	56	23	0
Building trades	4	0	0	0
Liquor dealers	20-10	70-50	36-23	0

working in lead and silver mines or engaged in should take particular care as to cleanliness. All working in lead and silver mines, or engaged in other occupations in which lead is encountered, should take particular care as to cleanliness. All the water drunk should carefully be covered to protect it from contamination, and the addition of sulphuric acid is advised as a useful prophylactic measure. Workmen should eat their meals outside the factory, and should carefully wash the face and hands and cleanse the nails before each meal.

Great care should be taken that the lead-impregnated dust in smelters is carried off through proper exhaust flues and precipitated, and that the rooms in which the workmen are engaged are kept in as neat a condition as possible. Proper respirators should also be worn if the exhaust flues are inefficient, and the clothing should frequently be changed and washed, that the particles of lead entangled in its meshes be not absorbed. Irritating fumes should be carried off by proper flues and hoods. Where this is not entirely successful, respirators impregnated with the appropriate neutralizing chemical should be worn. "Phossy jaw" has been found to occur chiefly in those with decayed teeth, and the greatest care should be taken by these workers that any cavities be promptly filled. The use of the red instead of the yellow phosphorous does away largely with the danger of phosphorus-poisoning in the manufacture of matches, and should be generally adopted.

In all factories sufficient protection to the lives and limbs of those employed should be insisted upon and, if necessary, enforced by appropriate legislation and inspection. Work rooms should have an ample light and air supply, and should be provided with means for safe and rapid egress in case of panic or fire. Many corporations have found it of economic as well as sanitary advantage to restrict the number of working hours, supply comfortable seats, work tables, well equipped lavatories, attractive surroundings and to aid employees in securing sanitary homes, wholesome food, uplifting mental diversion and sufficient exercise. Civilized communities cannot afford to passively tolerate occupations that are degrading to mind or body or that show a careless disregard of personal injury.

Neurosis from Occupation.

The loss of the natural coördinate action of related groups of muscles, already mentioned as occupation spasms or palsies, is most frequent in those exposed to severe mental strain or in those with neurotic tendencies. Occupations associated with great mental effort frequently lead to forms of *hysteria, neurasthenia* and *paralytic dementia.* To such affections *statesmen, artists, financiers, journalists, authors, lawyers, physicians, teachers* and *students* are especially predisposed. The comparatively isolated life of *ag-*

riculturists, with its tendency to brooding and introspection, seems to favor the development of *melancholia* and forms of *insanity.* Neurasthenia, therefore, is often a product of urban life, melancholia of rural life.

The *prophylaxis* of these conditions is obvious: relief from mental strain, physical exercise, and a closer association with nature for those predisposed to neurasthenia; the cultivation of the more attractive social diversions and relief from monotony, for those with melancholic tendencies, and in general the absolute interdiction of stimulants, narcotics and all forms of excess.

CHAPTER VII.

EXTRINSIC FACTORS OF DISEASE.

ANIMAL PARASITES.

PARASITES.

Living organisms either animal or vegetable that live at the expense of other organized beings (hosts) are termed *parasites.* Forms of life living upon dead organic or inorganic matter are designated *saprophytes.* These may be *messmates* in which case they live upon food collected by the host or they may pursue an independent form of existence. Obligatory parasites are those that live only on the tissues of hosts. Many forms, however, are optional, adapting themselves to a parasitic as well as a saprophytic existence. Parasites may excite pathologic processes by producing mechanical injury, causing tissue waste, or by liberating toxic substances. Those parasites usually designated as infectious organisms are injurious chiefly through the liberation of poisons. It should be noted that while for convenience we say that certain parasites produce disease, the process is, in reality, much more complex, for in the origin of disease structural and functional changes in the tissues have an important part. Similarly, we say that a fire is caused by a match, yet the blaze is a result of the union of oxygen and a combustible substance. The match, however, may be an essential inciting factor and so it is that parasites often prove an essential inciting factor in disease by destroying the equilibrium of health. The parasites concerned in disease production are found chiefly among the bacteria and molds, in vegetable life; the protozoa, worms and insects in animal life.

The Evolution of Parasitism.

For the most part, evolutionary changes taking place in organized beings, tend to a greater dependence of one form of life upon another. The primitive types must have subsisted entirely upon inorganic substances. Indeed, the first forms probably made use in large part of free elements or the simplest available compounds, and by a process of synthesis produced gradually more and more complex combinations. As the compounds thus produced became more akin to the bioplasms, of which organized beings are formed, it was but a simple step for certain forms of life to utilize them rather than perform the more difficult task of building up bioplasm out of the elements. Thus may have developed dependent, saprophytic forms of life subsisting upon products formed by other organized beings. In the natural tendency toward conservation of energy, it seems probable, certain life forms acquired a yet more direct method of acquiring nutriment by merely transferring and transforming to their own use the bioplasm more or less laboriously elaborated by other living things. Evolution is characterized by a tendency to the progressive increase of this parasitic form of existence. Indeed, the well known law regarding "*the survival of the fit*" expresses in one aspect a *progressive* and *triumphant parasitism.*

Among the lower vegetable parasites the changes outlined are known to take place with great rapidity. A few of the soil bacteria represent quite primitive forms of life, being able to use such elementary substances as oxygen and nitrogen and carbon dioxid. Other bacteria found in the soil are able to use the compounds thus formed and to make from them combinations sufficiently complex to serve as food for the higher plants. Again, other bacteria that may have sprung from the same root-stock are parasites living at the expense of the compounds formed in these higher plants. By evolutionary changes, consummated in a few generations, a saprophytic organism may become parasitic; while most parasitic forms can accustom themselves to a saphrophytic existence. As affecting human pathology, for example, many of the organisms responsible for pus formation rapidly lose their injurious properties when grown outside the body. By permitting the bacteria to live in the bodies of susceptible animals for a number of generations, their virulence against more resistant animals is often regained.

There is a group of bacteria including the *tubercle bacillus* and forms resembling it, that has a special interest in this connection. These organisms resemble each other in form, in manner of growth, and in their reaction to certain stains—being called *acidfast bacteria,* because when stained they resist the decolorizing action of the stronger acids. Besides the tubercle bacillus and the smegma bacillus, the group includes forms found in butter, upon grass, and in the manure of animals fed upon the grass. These vary widely in their pathogenetic activities. The *smegma bacillus* seems unable to invade or injure the living tissues. The *grass bacillus* shows limited pathogenetic properties that simulate in a milder way those of the tubercle bacillus. Again, tubercle bacilli of very limited virulence have been observed. It is not unreasonable to assume that the grass bacilli, at least, may represent an ancestral form of the organism of tuberculosis. Repeatedly entering the alimentary tract of herbivori with food, it is possible that these organisms have gradually accustomed themselves to the higher temperature of this new habitat, and to the animal nutriment; have acquired a resistance to the antagonistic action of the animal cells; and finally have been able not only to overcome this resistance, but also to invade the tissues with destructive effects. In this way it is possible that the virulent bacillus tuberculosis has been evolved. Having been disseminated among various species of animals, different properties have been acquired in each; and thus the differentiation into the forms special to the cow, the fowl, and man may have occurred.

While such evolution of the tubercle bacillus is in part suppositious and remains unproved, there is abundant evidence of the constant general tendency to the production of parasitic forms by some such process. In considering the invasion of living organisms by bacteria and the lower animal parasites and the means by which it may be prevented, the principle here declared is of great importance; for sanitary science must strive not merely to limit the range of activity of the known parasites, but also to *avert the evolution of disease-producing forms out of types now harmless.*

ANIMAL PARASITES.

PROTOZOA.

Infusoria.

Catarrhal or ulcerative inflammations of the intestinal tract have been attributed to the presence of *Calantidium coli, Cercomonas intestinalis* and *Trichomonas intestinalis.* These parasites may be acquired from hogs or other domestic animals, from contaminated earth or water.

Rhizopoda.

Of chief importance is *Ameba coli,* apparently an important factor in chronic dysentery and hepatic abscess. It is suggested that they may be acquired from cats. It is possible that future investigation will prove that ameba, otherwise harmless, play an important rôle in disease production by serving as intermediate host for bacteria.

Sporozoa.

Most important is the *malarial parasite* which has as its definite host and carrier, the mosquito. *Coccidia* occur in oxen, mice, salamanders, cuttle fish, centipedes, and from these animals or from moist earth in which they undergo a developmental cycle they may, in rare instances, be acquired by man.

Sarcosporidia occur in the muscles of mice, cattle and birds, producing cysts so minute as to be barely visible as whitish specks.

The chief mode of human infection would seem to be the eating of infected and imperfectly cooked meat.

INSECTA.

Insects may be harmful directly or because they serve as carriers of parasites. They may be injurious through their bites and venom, or by their invasion of the tissue.

The *larvæ* of various insects may develop upon, or within, the body, from eggs deposited upon the person or within the cavities of the body or upon food. The larvæ may develop in the nasal passages, the accessory sinuses, the ear, eyes, intestinal tract, vagina or wounds.

Caterpillars may cause a severe erythema and urticaria through poisonous cutaneous hairs. The irritation of the procession caterpillars (*Cnethocampa*) of Europe is notorious and urticaria may result without direct contact. In rare instances lepidopterous larvæ have been found in the intestinal contents.

Diptera.

Most of the *parasitic larvæ* belong to the family of flies. In the nose, in the external ear and their accessory sinuses, and in the conjunctiva, ova of the *blue-bottle flly* (*Musca vomitoria*), the *common flesh fly* (*Creophila*), the *botfl* (*Gastrophilus equi*), and *Lucilia macellaria* may be deposited and develop into larvæ that cause serious lesions. The presence of maggots in these places is much more common in tropic regions, and especially in persons of uncleanly habits. The *screw-worm,* the larva of Lucilia macellaria, found in tropic and subtropic North America, destroys both the soft and osseous tissues, and may penetrate from the nasal sinuses to the brain. In

44 cases there were 30 deaths. Dipterous ova may also be deposited in the ear, in wounds, and in the vagina after parturition. After ingestion of the eggs of the *common house fly,* the *bluebottle fly,* or the *flower fly,* the larvæ may set up a marked irritation in the intestinal tract. More or less local irritation may be produced by bites of *horse-flies* (*Stomyxes* and *Tebanus*). The larvæ of the ver Macaque (*Dermatobia noxialis*) of Mexico, the mecaco worm of New Granada, and the ver du Cayor (*Ochromyia anthropophaga*), of Africa, burrow beneath the skin.

Personal cleanliness, the protection of wounds and screening of rooms against flies are important preventive measures. From the normal sinuses or wounds these parasites may be removed by syringing with solutions of carbolic acid, mercuric bichloride or by appropriate forceps.

Siphonaptera.

The fleas are suctorial, wingless insects possessing great leaping power and closely related to the Diptera. While each kind seems to have a particular animal as its normal host, they often, for a temporary period at least, migrate to other species of animals. Thus, the hen flea, the rat and mouse flea, or the dog and cat flea may affect man. The common house-flea (Pulex irritans), is distinguished from those of the dog and cat by the absence of spinous combs about the head. The jigger flea, or chigoe, occurs in tropic and subtropic regions, infecting lower animals and man. After impregnation, the females burrow into the skin, especially of the sole of the foot and about the toe-nails, producing a vesicular or pustular inflammation. If the insect's greatly distended body be ruptured within the tissues, liberating the larvæ, serious inflammatory changes may follow. In the presence of chigoes particular care should be taken in repeatedly cleaning and removing all dust and litter from the floors of dwellings, stables and hen-houses. These should then be sprinkled with pyrethrum, solutions of carbolic acid, creolin or other insecticide. Daily baths should be taken, the feet and ankles protected by clothing and any fleas that have affixed themselves to the skin promptly extracted.

Hemiptera.

The Hemiptera are suctorial insects living upon the juices of animals and plants. The bedbug (*Cimex lectularis*) and various pediculi or lice (*Pediculus capitis, Pediculus corporis,* and *Pediculus pubis*), are the chief varieties of hemipterous insects that infest man. The liquid secreted by the crab louse is said to cause slaty blue spots, ("taches bleuatres"), upon the skin. Lice may be acquired from contact with infected persons, clothing or utensils. Methods of prophylaxis are considered under heading, "The Prevention of Disease Transmission by Insects."

Bedbugs are said to occur on domestic fowls, pigeons, swallows and bats. They are distributed over most parts of the civilized globe. Idiosyncrasy greatly influences the degree of reaction to their bites. The so-called "big bedbug" (Conorhinus sanguisuga) is a much more formidable insect, found throughout the southern United States and in South America. The adult forms are winged and as they probably fly from wooded areas into houses at night, they may be excluded by the use of screens. Their bites are often followed by serious inflammation.

ARACHNIDIA.

Many of the spiders and scorpions are venomous. Of the arachnids invading the body, the itch mite (*Scarcoptes scabiei*), the cause of scabies or *itch*, is the most important. In the sebaceous follicles, especially of the nose, a minute parasite, *.3 mm. to 9.4 mm. in length, the *Demodex* or *Acarus folliculorum* is often present. It may be an exciting factor in *acne*.

Ixodes.

The ticks, or wood lice, attach themselves to man or beast from grasses or shrubbery which they inhabit. They fill themselves with blood and may transmit disease. *Boophilis bovis* is a carrier of *Texas cattle fever*. The bites of the *Argas persious* of Persia and *Argas moubata* of Portuguese South Africa are often followed by a severe febrile illness, apparently due to the inoculation of a parasite. To prevent their bites houses may be fumigated by smoke or pyrethrum, beds should be placed above the ground and should be carefully screened.

Linguatula rhinaria (*Pentastomum tænioides*) is found in portions of Europe, and in the adult form invades the nasal sinuses, rarely in man, commonly in dogs, and occasionally in horses. The larval form (*Linguatula serrata, Pentastomum denticulatum*) occurs in the *liver, spleen* and sometimes the *kidneys*.

The harvest bug (*Leptus autumnalis*), or red flea, the larva of the *Trombidium holosericum*, is a minute, reddish parasite which burrows beneath the skin, usually of the wrist, and produces papular lesion, associated with intense itching. They may be destroyed by the application of sulphur or mercurial ointment.

ANNELIDES.

Of the *leeches* certain forms are aquatic and attach themselves to the integument of animals that enter the water. Other forms are found in bushes and grasses, from which they spring upon passing animals. Of the latter the *Hemadipsia* or *Hirudo Ceylonica* of Ceylon and parts of South America is most important. Not only may the bites cause painful ulceration, but death may occur from repeated small bleedings. In southern Europe and northern Africa the ***horse-leech,*** *Hemopis sanguisuga,* occurs, and may invade the nasal chambers, the trachea, or larynx, producing severe pain and repeated hemorrhages. The leech may gain entrance to the body through foul drinking water. By boiling or filtering all drinking water and by protecting the surface of the body, leeches may be avoided.

HELMINTHES (VERMES).

The worms parasitic in man comprise the ***nematodes,*** or round-worms, the *trematodes,* or sucking worms, and the *cestodes,* or tapeworms. The *nematodes* have an elongate, cylindrical body, varying in length from a few millimeters to one or more meters (1/10 to 60 inches); the head is not differentiated from the body, and they occur in pairs. They are oviparous or ovoviviparous, and are found in the intestinal tract, in the tissues, or in the blood- and lymph-vessels. The embryo or the adult form may cause disease.

The *trematodes* rarely exceed a few centimeters (1 ½ inches) in length and the head is undifferentiated. Certain forms are hermaphroditic. They live in the intestines and blood-vessels.

The *cestodes* consist of a minute head with suckers for attachment, a narrow neck and many segments or proglottides. They measure from 5 millimeters to several meters (¼ inch to 100 feet). Each proglottid contains both male and female generative organs. The complete worm is termed a strobile; the embryo, a scolex or measle. The strobile is always found in the intestinal tract; the measle in the tissues, especially the muscles.

To avoid infection by the intestinal parasitic worms, dependence should not be placed upon the inspection of meats and other foods alone. Measures of personal cleanliness, the sterilization of food-stuffs by cooking, and the prevention of insect contamination are of great value. The most important of these measures is thorough cooking. Smoking is not an efficient parasiticide, but many of the methods of pickling meats, slowly destroy the worms. As the manure from hogs or other animals may contain ova of some of these parasites, care should be taken in its use as a fertilizer for green vegetables, especially celery, lettuce and the like. The generally recognized measures to prevent water pollution should be observed.

NEMATODES.

The common *round-worm*, (*Ascaris lumbricoides*), occurs chiefly in the *small intestine*. In many instances it causes no disturbance, but occasionally, by migration into the *stomach, biliary passages, appendix, mouth, nose, eustachian tube*, or through the intestinal walls, or by the production of toxic substances, gives rise to serious trouble. If present in large numbers, serious reflex disturbances or intestinal obstruction may result.

The thread-, pin-, or seat-worm, the *Oxyuris* (*Ascaris*) *vermicularis*, occurs in the *colon* and *rectum* of children, and occasionally of adults. It rarely leads to serious symptoms, although there may be local irritation, and reflex disturbances. The eggs are constantly present in the intestinal contents of those affected. Through improper disposal of excreta, soil, drinking water and green vegetables may be contaminated. The eggs may also be carried by flies and other insects.

Uncinaria (anchylostoma) *duodenalis* or *hook worm* affects chiefly miners, tunnel makers, brick makers, diggers, farmers and others who come in direct contact with the soil. More common in the Mediterranean countries as Italy and Egypt, the disease has been found in all parts of Europe, and recently in America. The adult worm lives in the duodenum puncturing the mucous membrane and sucking blood, first at one point and then at another. The repeated blood abstractions, with the ensuing hemorrhages, the bacterial infection of the damaged intestine, and the interference with assimilation of food, together, according to certain authors, with the absorption of toxic products of the parasite, lead to anemia of a high grade in the host; miner's anemia, brick-maker's anemia, tunnel anemia, mountain anemia, uncinariasis. The eggs are deposited in the intestinal canal by the female parasites, but do not develop into adult worms within the body. After escaping with the feces each egg, if the environment is favorable, develops a single embryo. This lives in water or moist ground and gradually the sexes become differentiated and approach the adult form. The embryos may gain entrance to the body by the swallowing of infected water, food or dirt. It is improbable that they are spread by winds, as drying usually is fatal to them. Direct penetration of the skin from contaminated water is claimed by Looss.

The *prophylaxis* should embrace the use of uncontaminated or sterile drinking-waters only, and care as to personal cleanliness, particularly as related to the hands, finger-nails, and all substances placed in the mouth. To avoid the disease in sheep and other live stock, Stiles urges the systematic draining and burning of pastures. The soil should also be turned by plowing. To this may be added the importance of segregating or treating diseased animals with thymol, that reinfection of the pastures may not result. Infected stools may be sterilized by chlorinated lime or milk of lime. From loss of blood, digestive disturbances, and the action of toxic substances liberated by the parasites, a severe anemia may be produced.

The *whip-worm* (*Trichuris trichura, Trichocephalus dispar*) occurs often in large numbers in the intestines of Europeans and Asiatics. *Anemia, diarrhea,* and even *beri-beri,* have been ascribed to its action; but it is often present without symptoms, and care should be taken that they do not spread promiscuously over the soil.

Trichinella (Trichina) *spiralis* enters the alimentary canal, in a larval form, encysted in diseased pork. Within a few days it develops to maturity in the intestines, and gives rise to broods of embryos that invade, through the tissues or circulatory channels, the voluntary muscles. Here they become encysted and may retain their vitality for 15 or 20 years. They produce severe intestinal disturbances, eosinophilia and finally marked tenderness of the voluntary muscles. If the respiratory muscles be invaded by large numbers of embryos, death may result from asphyxia.

Hogs are usually infected by eating infected rats or meat. Care should be taken that the pig pens are kept clean and free from vermin, and that hogs are not fed with condemned meat unless this has been thoroughly cooked.

Food made of uncooked or imperfectly cooked pork should be strictly avoided. Hertwig found that pieces of pork the thickness of the thumb could be boiled for twenty-two minutes without killing the contained trichinæ, and showed that there was greater danger from cooked sausage in which the meat was coarsely minced than from sausage made from finely minced meat. Bloomer and Neumann have reported an epidemic involving nine persons in two Italian families that ate sausage made of coarsely minced pork scraps. The sausage had been boiled in its manufacture, and was usually fried for the table. This indicates the necessity for very thorough cooking. A temperature sufficient to coagulate protoplasm and turn the meat from the raw brown to the opaque cloudy color of cooked meat will kill the parasites. The methods of pickling and preserving hams and other portions of hogs by immersion and by injection with preservatives seems also to destroy them, for infection from the imported American meat in Germany is practically unknown. Inspection, while a safeguard, is expensive and not absolutely trustworthy, as carelessness or cupidity may permit the sale of diseased meat. Dependence should, therefore, be placed upon thorough cooking only.

The *Guinea-worm,* "thread worm of Medina" (*Dracunculus* or *Filaria medinensis*), undergoes an intermediate existence in certain fresh water crustaceæ. It develops in the subcutaneous tissues of man, and may attain a length of 60 to 100 cm. It produces marked local irritation and at times abscesses. It is usually removed by securing the extremity of the worm, which is near the surface of the skin, and coiling it about a small stick. By slowly winding the stick from day to day the worm may be gradually extracted without rupture. Should the body of the worm break beneath the skin, the liberation of embryos and possibly also of toxic substances leads to abscess formation and severe local disturbances.

Several forms of *filaria* live in the blood- and lymph-vessels, the name *Filaria sanguinis* being given to all. The four principal varieties are the *Filaria nocturna* (*Filaria bancrofti*), *Filaria diurna* or *loa, Filaria perstans*, and *Filaria demarquayi.* The *Filaria nocturna* (*Filaria sanguinis hominis*) has been especially investigated by Manson, who has shown that it is inoculated by the bites of certain mosquitoes. In man, the adult lives in the lymphatics, the embryos entering the circulating blood in large numbers at night, or while the patient is resting. The Filaria diurna is usually found beneath the conjunctiva. The Filaria perstans has been found in the bodies of persons afflicted with the peculiar disease "African lethargy," or "sleeping-sickness of the Congo." Its precise relation to sleeping sickness is as yet unsolved. The methods of preventing the dissemination of filaria by mosquitoes, is considered in a later section.

TREMATODES OR FLUKES.

Bilharziosis, a disease chiefly occurring in Egypt, is caused by the Schistoma or *Schistosomum hematobium* (*Distoma hematobium, Bilharzia hematobium*). The adult lives in the *blood* and produces eggs with pointed spurs that lead to ulcers in the walls of the capillaries, and are a frequent cause of the endemic hematuria of Egypt. The worms are found chiefly in the portal system and may give rise to *intestinal hemor-*

rhages. The disease often persists for many years.

Fasciola hepaticum (*Distoma hepaticum*) is a fluke, inhabiting the biliary passages, giving rise to ulceration, icterus and severe hepatic disturbances that may end fatally. The ova may be found in the stools.

Distoma westermanni is a bronchial fluke that is the cause of an epidemic parasitic *hemoptysis* occurring in China, Japan and Formosa.

The precise method of invasion of the body by trematodes is obscure. It is possible that insects serve as intermediate hosts. The disinfection of the discharges of those affected should be practiced and methods to prevent the contamination of food or drinking water observed.

CESTODES OR TAPEWORMS.

Taenia saginata or *mediocanellata,* the unarmed or beef tape worm, is the most common tape worm in the United States. The measle or scolex occurs in the muscles of cattle, and when ingested, develops into the adult (strobile) in the intestinal tract of man. The disease is preventable by the avoidance of uncooked beef as food.

Much less common in America is *Taenia solium,* the armed or pork tapeworm, the measle of which exists in the flesh of swine, the adult in the *intestine* of man. Occasionally, from the ingestion of the eggs, the measle invades the human *muscle,* producing small *cysts,* and is then called the *Cysticercus cellulosæ.* Cysticerci may likewise occur in the *brain.* The measures of prevention are similar to those advocated against trichinella.

Bothriocephalus latus (the fish tapeworm or pit head) is the largest of the tapeworms of man

It chiefly occurs about the lakes of Neufchatel and in Scandinavia, and may occasion severe anemia. The measle is found in certain fish, especially the pike and turbot, and it is by eating the raw flesh of affected fish that the disease is contracted. The parasites are destroyed by cooking but methods of smoking or pickling fish may be unreliable.

Taenia echinococcus, the dog tapeworm, occurs only as an embryo in man, being found as an adult tapeworm in the intestine of the dog. It is the smallest of the tapeworms, having but four segments and being 4 mm. in length. After ingestion the embryos invade the walls of the intestine, enter the organs, and produce echinococcus or *hydatid cysts.* These may be multiple and may acquire large dimensions. In man they are more frequent in the liver, but may occur in any organ. The eggs are present in the intestinal contents of affected dogs, and the disease is usually contracted through close association with these animals.

Rare forms of tapeworm in man are *Taenia nana* (the dwarf tapeworm), that measures 2 to 3 cm. in length, and is believed to pass a larval stage in an insect or snail; *Taenia cucumerina* (*Taenia canina, Taenia elliptica*), a common tapeworm of cats and dogs, that passes an intermediate stage in fleas; and *Taenia flavopunctata,* of which little is known.

Diagnosis.

The recognition of intestinal parasites plays an important part in the prevention of these diseases. Usually it may be accomplished by examining the stools for the adult forms or the eggs. A small drop of the liquefied fecal matter taken from near the surface, should be spread out in a drop of water on an ordinary slide, covered with a cover-slip, and examined under a ⅓ inch or 8 mm. objective. If this examination prove negative, Stiles recommends a method of washing and sedimenting the feces. One or two ounces of dry or fresh feces are mixed with from one to four pints of water, strained, washed thoroughly, permitted to settle, and then decanted down to the sediment. This procedure is repeated as long as any matter will float. Finally, the agitation is conducted in a narrow bottle or graduate, and after thorough settling the sediment is examined. If there is much coarse material, this may be removed by washing the finer portions through a sieve. Centrifugation is rarely necessary.

For the detection of *Strongyloides intestinalis* (*Anguilla stercoralis*), Leichensten suggests that a small excavation, into which a little water is poured, be made in the solid feces. If the parasites be present, they will usually be found in a short time in the water, especially if the preparation be kept at a temperature from 30° to 35° C. (86° to 95° F.)

The eggs of the uncinaria are embryonic ovals with a thin shell, the protoplasm being unsegmented, or in the early stages of segmentation. Similar eggs are those of *Ascaris lumbricoides, Oxyuris vermicularis* and *Trichocephalus dispar.* The first have a thick, gelatinous, often mammillated covering and the protoplasm is not segmented. The second have a thin asymmetric shell, one side of which is nearly straight, while the eggs of whip-worms possess a smooth, thick shell, apparently perforated at each pole, and containing unsegmented protoplasm.

In examining for segments of tapeworm or for the round worm of larger size the fecal material should be screened through a coarse sieve of metal or gauze. For *Amoeba coli,* particles of the freshly passed dysenteric stools should be placed on a warm slide and examined at once. When kept warm and in a fresh condition, the amebæ continue their characteristic movements, and so are easily recognized.

CHAPTER VIII.

EXTRINSIC FACTORS OF DISEASE.

VEGETABLE PARASITES.

BACTERIA.

Morphology.

Bacteria are minute unicellular plants resembling algae, that, as they seem to multiply by simple fission, are grouped under the head *schizomycetes.* They show three chief varities as to form, being either (1) globular or oval (*cocci*), (2) elongate or rod-shaped (*bacilli*) or (3) spiral (*spirillæ*). By peculiarities in their method of division, or by the formation of mucilaginous products, cocci may occur, singly (*monococci*), in pairs (*diplococci*), in fours (*tetragenococci*); forming cubical figures (*sarcinæ*), chains (*streptococci*) or irregular clusters (*staphylococci*). A number of organisms of a higher type such as those of actinomycosis and madura foot, although usually classed with bacteria, resemble molds. The bacillus of diphtheria and of tuberculosis indicate by their tendency to form branches, that they also are of a higher class. Bacteria often show *pleomorphism* or variations in form. Thus a diplococcus isolated from erysipelas may grow as a streptococcus in artificial media, the bacillus of plague often resembles a coccus and the diphtheria bacillus is subject to variations in length, breadth and in the form of its poles. From conditions unfavorable to growth, bacteria may develop marked irregularities in shape, termed ***involution forms.*** Peculiarities in form have no constant relation to peculiarities in function, or to the pathogenicity of bacteria, nor are they, as a rule, sufficiently destructive to enable the interpretation of species. Bacteria consists chiefly of an albuminous substance, together with variable amounts of fat and carbohydrate, enclosed in a cell wall and apparently contain a large nucleus. Their unit of measurement is the ***micron*** or micromillimeter $({}^{1}/_{25,000}$ inch) represented by the Greek letter μ. Cocci have an average diameter of 1 micron, the bacilli an average length of about 3 microns, while their width is usually less than 1 micron. Some are so small that they pass through the closest filter and are with difficulty recognized under the highest magnification; others so large that they have been detected by a simple lense. A number of the bacilli are flagellate or have projecting hair like processes (flagellae), often important as organs of locomotion. Some bacteria as *Bacillus typhosus, spirillum cholerae, Bacillus coli communis* are motile; others, as most cocci, *Bacillus anthracis* and *Bacillus tuberculosis*, have little or no motion.

Reproduction.

Apparently bacteria multiply by simple fission, this under favorable conditions occurring at such short intervals as to give them enormous reproductive powers. With certain species when the conditions for growth become unfavorable, granules appear within the bacillus that collect and finally are transformed into a refractile globule or oval mass surrounded by a tough, resisting capsule. These *spores* have a much greater resistance to unfavorable influences than the original bacillus, so that more powerful bactericidal measures are required against *sporogenous* than *asporogenous* bacteria. Under favorable surroundings each spore liberates a single bacillus from which it is evident that the object of spore-formation is to perpetuate the life of the species rather than for reproduction. *Bacillus anthracis, Bacillus edematis maligni,* and *Bacillus aerogenes capsulatus* are the principal sporogenous bacteria concerned in pathologic processes.

Life Requirements.

Heat, moisture and appropriate nutriment are essential to the vital activities of bacteria.

Heat.—Those forms invading man grow best about the temperature of the body, 37° C. (98 ⅗° F.). At lower temperatures they become dormant, and freezing, especially alternate freezing and thawing, may gradually destroy them, although many individual bacteria withstand a prolonged exposure to the temperature of liquid air. In general, *refrigeration* is to be considered as an antiseptic rather than a bactericide. As the temperature is raised bacteria first *attenuate* in virulence and then are destroyed. A number perish at a temperature of 50°-55° C. (122°-131° F.) and few are able to withstand a temperature of 65°-70° C. (149°-158° F.) probably because this is sufficient to coagulate protoplasm. Spores may endure a moist heat of from 80° to 100° C. or even more, while much higher degrees of dry heat are borne.

The varying resistance of pathogenic bacteria to heat is shown in the following table:

THERMAL DEATH-POINT OF BACTERIA

Organism	Observer	°C.	°F.	Exposure (Min.)
Spirilla cholerae	Sternberg	52	125.6	4
Bacillus typhosis	Sternberg	56	138.8	10
Bacillus anthracis	Chauveau	54	129.2	10
Bacillus mallei (of Glanders)	Loffler	55	131.0	10
Pestis bubonica	Rosenau	70	158.0	10
Bacillus diphtherae	Loffler	60	140.0	10
Streptococcus erysipelas	Sternberg	54	129.2	10
Staphylococcus p. aureus	Sternberg	58	136.4	10
Diplococcus pneumoniae	Sternberg	52	125.6	10
Gonococcus (1 observation)	Sternberg	60	140.0	10
Anthrax bacilli		54	129.0	10
Anthrax spores	Sternberg	100	212.0	4
Tetanus spores		100	212.0	10
Tubercle bacilli	Schatl & Fischer	100	212.0	4
Tubercle bacillus		80	176.0	5
Vaccine virus	Carston & Coest	54	129.2	10
Hydrophobia Virus	Sternberg	50	140.0	10

In general the results here given represent exposures to moist heat. They do not in all cases show the minimal exposure required. Delepine found that anthrax spores are killed by a current of saturated steam free from air, in thirty-five seconds. Different species of the same organism may vary in resistance. Finally, it should again be noted that virulence usually is lost at a much lower temperature than vitality, and one should remember that no known microorganism capable of exciting disease, can withstand boiling water at a temperature of 100° C. (212° F.) for ten minutes. Thus, in practical disinfections, microorganisms of greater resistance may be ignored.

Moisture.—The bacterial body is composed of about 85 per cent. water, and few bacteria will grow except in liquids or upon moist surfaces. Dryness produces attenuation in virulence and finally the death of the microorganism, the time required varying with the species, the degree of dryness, temperature and the protection afforded by albuminous or other associated material. Upon this factor probably depends the relatively greater healthfulness of dry climates, soils and dwellings. Spores may resist prolonged drying, yet are unable to develop into bacteria except in the presence of moisture. Desiccation, therefore, is a very important factor in natural disinfection, and, in general, has an important bearing upon sanitation. It has been employed for ages as an antiseptic in the preservation of meats and dead bodies.

Nutriment.—Although a few forms are able to subsist upon simple compounds or even inorganic matter, most bacteria require proteid food. The addition of certain salts and, for some species, glycerin, glucose and other substances facilitates their growth. Most bacteria grow best in a neutral or slightly alkalin medium, while acid media are suitable for molds. Virulence is often best maintained when the bacteria live in a medium of unaltered animal proteids. For example, to retain the virulence of streptococci, pneumococci, or plague bacilli, it is customary to seal them in glass tubes with the blood of a rabbit. Upon blood their virulence is much better maintained than upon bouillon made of meat. The gonococcus does not grow upon the ordinary media made from the flesh of lower animals, while colonies form upon human blood serum.

To render their food diffusible, bacteria elaborates various *enzymes; proteolytic, amylolytic, fat splitting, inverting,* and *milk curdling.* Thus, they are all able to change starches into dextrose, and dextrose into sugar; to invert cane sugar into glucose, to convert proteids into albumose and peptone; break up fats into glycerin and fatty acids and coagulate milk. We must not conclude that these products are necessarily similar to those produced by the action of the saliva, gastric juice, pancreatic secretion and the bile.

Products of bacterial digestion may be intensely toxic in man.

Air.—Bacteria may be unable to vegetate without free oxygen (*obligatory aerobic bacteria*), or like the tetanus bacillus and the bacillus of malignant edema unable to grow in the presence of free oxygen (obligatory anaerobic bacteria). Forms such as *bacillus anthracis, bacillus diphtheriae, bocillus typhosus* and *streptococcus pyogenes,* capable of growing without oxygen as well as with it, are termed *facultative anaerobic bacteria.* Within the body anaerobic bacteria are only able to multiply when protected from the air or associated with some oxygen absorbing species.

Light.—As a rule actinic rays of light interfere with bacterial growth and development, and the more intense rays have destructive action. Dark or dimly lighted places, therefore favor bacterial development. The dust from rooms occupied by persons with pulmonary tuberculosis is much less apt to contain virulent tubercle bacilli if the rooms are flooded by daylight.

Toxic Products.—Bacterial infections are almost universally bacterial intoxications. As a result, the toxic products of bacteria have an especial importance. Mention has already been made of *toxic albumoses, peptones* and *fatty acids* that result from the action of bacteria upon nutritive media. More important are the diffusible toxic substances (toxins) elaborated by certain bacteria. Among these are the most poisonous substances known. The precise nature of these toxins is obscure, as they have never been isolated. Roger concludes that the toxin of diphtheria can poison a living being 20,000,000 times its own weight. Even this toxicity seems to be far surpassed by the toxin formed by bacillus tetani. The toxin produced by species of bacteria is as distinct as the alkaloids formed by different species of plants. Note, for example, the differing functional reactions associated with tetanus, cholera, and malignant pustule. *Ptomains* may be derived from toxins. Proteid substances found in the bodies of bacteria are toxic. These *bacterial proteids* are liberated upon the death and disintegration of bacteria and may be obtained in solution by grinding the bacterial bodies, boiling them in solutions of glycerin or other methods. Tuberculin made from tubercle bacilli and mallein made from the bacilli of glanders, are examples of solutions of bacterial proteids. When introduced into the body these substances are followed by changes in cellular function and in the composition of the normal fluids of the body. By using graduated, repeated doses of toxin the body in time develops immunity, and in the blood serum is found an element (antitoxin) capable of neutralizing the action of toxin introduced into susceptible animals. In general, the action is specific; the antitoxin of diphtheria protecting against diphtheria toxin, that of tetanus against tetanus toxin.

By the introduction of living or dead bacterial bodies an antibacterial form of immunity may be produced, so that in an animal so treated, bacteria introduced into one of the serous cavities will promptly collect in clumps (agglutinate) and then dissolve. (*Pfeiffer's phenomenon.*) Yet the animal's serum fails to show this solvent (lysogenic) action outside the body unless serum from an untreated animal be added. Similarly when introduced into the body of an untreated animal it may render its body fluids capable of dissolving bacteria. These various reactions contain the essence of our present knowledge regarding infection and immunity. Their nature is obscure, but pending more exact information many bacteriologists have accepted, as a working hypothesis, the theory of Ehrlich.

To render the lateral-chain-theory the more intelligible we shall try and consider it in a simple fashion, avoiding many technical expressions, and reference to the large amount of the intricate experimental evidence upon which it rests.

Ehrlich's Lateral-Chain-Theory.

Individual cells making up the organism may be assumed to consist of a central body having a multitude of affinities (*side chains*) ready to receive nutritive substances. These affinities (*receptors*) unfortunately, also permit the union of poisonous substances with the cell, often with disastrous consequences. However, it is a physiologic rule that the utilization of a cell product is followed by its renewal and often by its overproduction. And so the utilization of cell affinities in the union of the poison with the cell may be followed, especially if the poison be repeatedly introduced, by a great regeneration of receptors and the overplus may escape into the blood. Should more of the poison now be introduced into the body these free, circulating affinities unite with it before the cells are reached. Thus the dagger finds a scabbard outside the tissues and the cells go unscathed. As it is also assumed that the toxic substances are only able to unite with the cell by means of certain free combining elements (*haptophose group*) it is obvious that when these enter the free affinities circulating in the blood the toxic substance proper (*toxophose group*) is no longer able to unite with cells and, therefore, is innocuous. This explains why the introduction of a poison—say nicotine, arsenic or a bacterial toxin, into the body at first produces symptoms; the poison uniting with the cell and producing functional or structural disturbance. After repeated introduction the symptoms resulting from the poison gradually grow less, excessive affinities are being formed and are thrown into the blood. Finally, the poison no longer produces ill-effects—the cells have established a persistent over-production of the specific affinity—immunity has been attained. The immunizing substance thus thrown into the blood when efficient against a toxin is antitoxin. As the immunity thus produced is specific, acting only against a particular poison, it is assumed that each toxic substance has its own special antitoxin. The number of receptors possessed by cells must, therefore, be almost innumerable.

Lysins.—When foreign cells such as bacteria, red or white blood corpuscles, epithelial cells, or spermatozoa, are introduced into the blood, special receptors are regenerated and thrown into the blood in the manner above described. Instead of being termed antitoxin this circulating substance is termed, by various writers (*immune body, intermediary body, ceptor, substance-sensibilatrice, fixator* or *copula*). Strangely enough this immune body alone does not affect the foreign cells, but it serves as a go-between, linking to them a second substance found in the blood of all normal animals. This second substance possesses ferment-like qualities and when linked to the foreign cells soon dissolves them. It has been variously termed *complement, complementary body, addiment, alexin* or *cytase.* In action the linking (immune) body is specific. Thus, when generated by the injection of tetanus bacilli, it will unite the bodies of tetanus bacilli to the ferment substance, but not those of diphtheria bacilli or foreign blood cells. As a result we have *hemolysins* active only against red blood corpuscles, tetanolysin active only against the bacilli of tetanus, staphylolysin against staphylococci and similar substances. The immune body is quite stable, while the complementary body, which seems to be a product of the leucocytes, disappears from blood on standing or moderate heating.

To be able to destroy invading bacteria, the animal body must contain not only sufficient complement, but also the proper form of immune body to render it active. Thus it is, that normal animals with sufficient complement but no immune body, fail to resist bacterial invasion, while immunized animals may suddenly lose their resistance because they have exhausted the supply of complement. In explaining racial or *natural immunity*, Ehrlich assumes that the body cells were formed with the special receptors that enable the toxic substance to effect a combination, absent; or, that the blood contains some special salts or other ingredients that make neutralizing unions with the poison.

While the lateral-chain-theory is admitted to be imperfect, it is in accord with and seems to interpret a large mass of experimental evidence.

CHAPTER IX.

THE DIFFUSION OF THE FACTORS OF DISEASE.

INVASION OF THE BODY.

Microorganisms constantly enter the human body, being inhaled with the air we breathe, swallowed with our food and gaining entrance by way of the broken or unbroken skin, or mucous membranes through the contact with contaminated objects. The number of bacteria with which the body has to contend varies greatly with the environment, being largest in urban life, and especially amid the unsanitary conditions of "slums" and "congested districts," and, as a rule, least amid rural surroundings. The body is well supplied with natural defenses, entirely sufficient against ordinary assaults, but becoming inefficient when the number or virulence of the invading parasites is great.

Thus, there are surfaces covered by epithelium to limit or prevent the entrance of bacteria or their products, tissue cells that supply antidotal substances to combine with and neutralize their toxic compounds; or their products, phagocytic cells that may gather to destroy them; lymphoid accumulations that may yield lysogenic substances to disintegrate and dissolve parasitic cells; while the body-fluids contain principles unfavorable to the growth of many bacteria.

Relative Resistance of the Different Tissues.

The different tissues and organs of the body not only vary greatly in their ability to resist pathogenic organisms, but also show degrees of resistance varying with the character of the parasite. For example, the tubercle bacillus most frequently affects the lymphatic glands, the lungs, bones and serous membranes. Less frequently it attacks the liver, spleen, kidneys, adrenals or skin. It infrequently produces serious disease of the heart, thymus gland, nerve-centres, adipose tissue, or voluntary muscles. The pneumococcus invades the mucous lining of the respiratory passages and the serous membranes, but rarely causes disease of other tissues, while the gonococcus finds the mucous membranes especially vulnerable, rarely affects the larger serous membranes, and has no effect upon the skin. On the other hand, there are many forms of parasites, such as those of tinea and scabies, that only invade the tissues of the skin, while trichina chiefly affect muscular tissues. The pus-forming organisms may produce the greatest destruction in parts having poor vascular supply, such as the adipose and fibrocellular tissues. The resistance of certain organs may also be influenced by *evolutionary* and *developmental changes.* For example, apparently useless remnants, such as the vermiform appendix are more vulnerable to parasitic invasion than actively functionating organs. Woods Hutchinson suggests that the greater vulnerability of the lungs to tuberculosis and other infectious processes may be ascribed to the fact that these organs were among the last evolved in the evolutionary process, the organs of more remote origin having a greater stability and resistance acquired through ages of functionating.

Supernumerary parts may lack the resisting powers of normal organs.

The Skin.

The well-known experiment of Gallé demonstrated that bacteria could penetrate the unbroken skin. After rubbing a culture of the staphylococcus into the forearm, a carbuncle surrounded by isolated furuncles promptly developed. Furuncles usually occur on hairy portions of the body rubbed by the clothing, such as the posterior portion of the neck in apposition to the collar, about the shoulder-blades, where fragments of dirt falling down the neck are caught and retained by the shirt, and portions of the wrist in apposition to the cuff. In such cases dust is most apt to be rubbed into the skin. In these infections the causal organisms probably usually reach the deeper layers of the skin along the hair follicles and sebaceous glands. Babes succeeded in inoculating a guinea-pig with glanders by so rubbing an ointment containing the bacilli into the skin that penetration into the glands was favored. It is also possible that bacteria may enter through the sweat-glands, but this is less probable, as the flow of perspiration usually tends to prevent their entrance, and practically furuncles are not found upon portions of the body, like the palms and soles, that are devoid of hair follicles. Apart from the pathogenic cocci, few bacteria are able to penetrate the unbroken skin in sufficient numbers to cause disease. Thus, the dictum of Wyssakovitch that the epithelial cells, while they maintain their integrity, protect the underlying structures and the general system against bacterial invasion, is in large part true. Persons who handle dead bodies occasionally develop localized tuberculous lesions (dissecting porter's wart), but these occur on portions of the hands subject to abrasion, and it has not been shown that the tubercle bacillus can penetrate the unbroken skin. Syphilitic virus can occur without a superficial lesion of the skin, although instances of syphilitic infection through the skin without perceptible lesion or chancre are recorded, this is very exceptional.

Among the molds that invade the skin may be mentioned those causing *favus, sycosis, herpes tonsurans* and *pityriasis versicolor.* Of the smaller animal parasites, the embryos of *uncinaria duodenale* have been observed to penetrate hair follicles of the unbroken skin. The *itch mite* burrows in the upper layers and the female of the *chiggre flea* buries itself in the skin. The ova of various *Diptera* may be deposited in unprotected wounds, causing them to swarm with maggots. *Demodex folliculorum* invades the sebaceous follicles. With the exception of the uncinaria, none of these parasites invades the internal organs.

Dermatobia noxalis of Central America and the larva of the *cayor fly* of Africa burrow beneath the skin and produce suppurative local lesions.

Wounds.—Organisms able to invade the uninjured skin may the more readily enter through breaks in its continuity. In this way infection may occur by any of the pus-forming bacteria, by the bacilli of tuberculosis, glanders, tetanus, plague and malignant edema, the fungi of actinomycosis and madura foot, the virus of syphilis, and other pathogenic agents. For infection, the lesion needs be very slight, the prick of a thorn being sufficient to produce the infection of madura foot, and the puncture of a rusty nail to cause tetanus. A scratch or slight abrasion will permit the inoculation of vaccinia, syphilis or tuberculosis. Mammary abscesses may occur in sequence to slight fissures of the nipples.

Of organisms that may be inoculated through the skin by mosquito bites, may be mentioned the *malarial* and other *hematozoa,* the organism of *yellow fever,* and forms of *filaria.*

In freely open wounds the danger of serious infection is relatively less than in narrow, punctured ones, provided no large serous surface be opened. In such wounds the free access of oxygen inhibits the growth of the bacteria of tetanus, and of malignant or gaseous edema, while the free drainage favors the removal of all pathogenic organisms. Accumulations of fluid in wounds, forming the so-called "dead spaces," are favorable to bacterial multiplication, and by pressure tend to interfere with the protective action of the adjacent tissues. *Drainage tubes* and *wound* packing, if not guarded, favor the entrance and multiplication of bacteria in wounds. Sutures and ligatures may not only form channels for bacterial invasion, but by pressure cause tissue anemia and devitalization, so that the bacteria have less resistance to overcome. It is claimed that saprophytic bacteria placed upon fresh wounds may be detected in internal organs within fifteen to twenty minutes, indicating the rapidity of the invasion. When granulations cover the wound, the danger from septic absorption is diminished. The older surgeons, appreciating this, permitted the flaps of amputation wounds to granulate before coapting them.

The Nose, Mouth and Pharynx.

The *mouth* constantly contains large numbers of bacteria, most of which are harmless. In many mouths there are also present pathogenic organisms of low virulence. They may invade the tissues and produce disease, should any cause sufficiently reduce the cellular resistance. This may explain the origin of the so-called ether pneumonia. Pneumococci present in the secretions of the mouth are inhaled into the lungs during anesthesia, and favored by the depressing conditions incident to operation, excite inflammation. Diphtheria bacilli often remain for months in the secretions of the mouth and *throat,* especially in those who have had, or have been in contact with the disease. Such persons are a constant menace to *nonimmune* individuals with whom they associate. Diphtheria bacilli may also remain in the pharynx, larynx or nose for many weeks. The *tonsillar crypts* may harbor various cocci with pathogenic tendencies. Miller has shown that certain saprophytic organisms act upon the starchy food collected about the *teeth*, with the production of lactic acid. This gradually dissolves the mineral part of the tooth structure, whereupon other bacterial forms penetrate and destroy the decalcified portion, leading to dental caries. The *nose* is protected against bacterial invasion by the presence of a mucus, unfavorable for bacterial growth, and a lining of ciliated cells, that tend to remove foreign particles. Besides this, leucocytes and other cells are present that probably exert a bactericidal action. Parke and Wright found that the nasal mucus contains comparatively few bacteria, and that it had a bactericidal action upon the anthrax bacillus, although little or none upon many other germs studied. Rats may be infected with plague by merely touching a smooth rod that has been dipped into a virulent culture to the mucosa. The organisms of *rhinoscleroma* and *glanders* invade the mucous membranes of the nose and palate. Of the animal parasites, the ova of *dipterous insects* may be deposited in the nose and the larvæ (maggots), may occasion not only marked inconvenience, but even fatal disease. The *screw-worm,* or larva of *Lucilia macellaria,* may penetrate the nasal mucosa and even destroy the cartilages and bones. More rarely, certain *Pentastomes,* as the larvæ of the *Linguatula rhinarie* and *Porocephalus constrictus* invade the nose, its accessory sinuses, and even the internal organs, as the lungs, liver and kidneys.

Accessory Sinuses.—From the mouth and nasopharynx, infection may spread to the ethmoidal or frontal cells, to the antrum, the internal ear, or the lachrymal duct and conjunctiva. Such extensions occur in the exanthemata, especially *measles, scarlet fever* and *smallpox,* and in *diphtheria, tuberculosis* and other zymotic conditions. The most frequent of the serious infections is that of the *internal ear*, which often leads to the perforation of the drum-head, infection of the mastoid cells, necrosis of the temporal bone, and, at times, septic infection, through contiguity of the lateral sinus and cerebro-substance with the production of *thrombophlebitis* and *cerebral* or *cerebellar abscess.* For these serious complications, *measles* and *influenza* are especially responsible. The tubercle bacillus may remain in a diseased middle ear for years, and finally light up a generalized infection.

These complications suggest the attention that should be given to the nasopharynx during and after the exanthemata, diphtheria, influenza and other infections involving this region. Residual catarrh should be treated, and adenoids, polyps and enlarged pharyngeal tonsils reduced in size or removed.

Infection through the *external ear* is less important, and usually results only in localized abscesses or furuncles of the meatus. Infection of the internal ear through the meatus is uncommon. The *lachrymal ducts* are not infrequently involved in rhinitis, with resulting troublesome forms, *dacryo-cystitis* and even *lachrymal sinuses.*

The conjunctiva is often infected directly through contact with towels, fingers, dust and other objects carrying infectious organisms. *Gonorrhea, trachoma,* and other forms of purulent *ophthalmia* are diseases most frequently transmitted in this way.

Antral infection may result from the extension of rhinitis, or through a diseased tooth, the root of which enters its cavity.

Gastro-intestinal Tract.—At birth, no microorganisms are normally present in the alimentary canal, but in twelve or eighteen hours bacteria appear in the intestinal contents, and thereafter are present throughout the life of the individual. The stomach, with its acid secretion, contains fewest bacteria, while the contents of the large intestines contain the largest number. In milk-fed babies two organisms are found to be constant and to predominate over all other varieties—*bacillus coli communis,* which has been noticed in largest numbers in the lower bowel, and *bacillus lactis aerogenes,* which appears to predominate in the upper part of the infantile small intestine. There are also lesser and variable numbers of other bacteria, yeasts and molds. The constancy with which microorganisms are found in the stomach and intestines in health has very naturally suggested that they play an essential part in the process of digestion.

The results of the experiments of Nuttall, Theirfelder and Schottelius upon guinea-pigs and chickens to determine this, are not conclusive.

Observations made in infants and adults indicate that bacteria are not essential in the normal digestive processes. Despite the repeated accessions of large numbers of bacteria in the act of swallowing, the stomach and ileum—portions of the alimentary tube most active in the digestive processes—contain relatively the smallest number of bacteria, while in the colon, in which there is the least digestive action, bacteria are found in greatest number. It is probable that, were it not for the repeated accessions of bacteria through the esophagus, the stomach and upper bowel would speedily become sterile. Van Puteren studied bacteriologically the contents of the stomach in healthy babies, and found that in 18 per cent. of the nursing infants, whose mouths were carefully washed out before feeding, the gastric contents were sterile, a condition that could hardly be present were bacteria essential to the digestive processes. Many tissues show a constant tendency to inhibit, remove or destroy bacteria, and the leucocytes seem to be engaged in a continuous warfare with microorganisms.

The digestive action of bacteria secured from the gastro-intestinal tract, is often feeble as compared with the action of the normal ferments. Moreover, injurious compounds are frequently produced. For example, the formation of peptones by bacteria may be but a step in a putrefactive process, the peptones formed being finally converted into various end-products of putrefaction, many of which are toxic. In the action upon carbohydrates bacteria form such irritating substances as alcohol and acetic and lactic acids, while from the fats various disagreeable and toxic acids are evolved.

Germ-free solutions of the normal ferments seem to retain their digestive powers. There is, therefore, ground for believing that bacteria are not essential to the digestive process, and it would seem that their constant introduction necessitates a continuous greater or lesser expenditure of resistive force on the part of the organism.

Of the bacteria that may directly invade the body through the walls of the alimentary tract, we have the microorganisms of *typhoid fever, cholera, tropical dysentery* (including the bacillary and amebic forms), and other diseases. Booker believes that excessive numbers of the colon bacillus and *bacillus lactis aerogenes* may be responsible for the milder forms of diarrhea. *Bacillus proteus vulgaris* seems to be responsible for more serious and chronic forms, while the very serious toxic and often chronic types are particularly associated with streptococci and other micrococci. All of these organisms may be present in large numbers in milk.

Most of the *animal parasites* comprising the round-worms, flukes and tapeworms are acquired by the ingestion of infected food or water, as has been set forth in a previous chapter. The eggs of various *insects* may be swallowed and the larvæ may develop within the intestinal tract; among such, the house-fly, the flower fly, bluebottle fly and other Diptera may be mentioned. Instances in which the larvæ of beetles and moths have occurred in the intestinal tract are also on record.

Respiratory Tract.

That solid particles frequently enter the pulmonary alveoli is proved by the frequent finding during postmortem examinations of grit diffused through the lungs.

If such coarse particles may gain entrance to the lungs during life, it is evident that minute parasites may likewise be conveyed. Experimentally, infections have been produced by inhalation, but, as a rule, with considerable difficulty, and at present it is generally believed that under the ordinary conditions of life, the lungs are rather infrequent portals of entry of infection.

The localization of disease in the lungs is not a proof of primary invasion through the respiratory tract. The causal agents of many respiratory diseases are now believed to enter through the lymphatics from the nasopharynx or, by way of the thoracic duct from the gastro-intestinal or other remote tracts. The evidence that Wasden puts forward that yellow fever and typhoid are respiratory infections is insufficient, and is at variance with established knowledge. The colonization of bacteria in the lungs depends more upon the relative susceptibility of these organs than upon the portal of entry. The lungs are guarded by the various protective devices of the upper respiratory tract, so that pulmonary infection is much more likely after tracheotomy or laryngotomy. An important mode of infection is by the inspiration of infectious mucus or food.

This is especially apt to take place during anesthesia (*inspiration* or *ether pneumonia*), in conditions of paralysis of the pharynx, profound asthenia, or after intubation. Parasitic *molds,* including varieties of the aspergillus and mucor, are occasionally carried to the lungs in respiration and produce disease. One of the most important of these is *Aspergillus fumigatus.*

Genito-urinary Tract.

The bacteriology of the female generative organs has been investigated by Hausmann, Winter, Doderlein, Kronig, Menge, Williams and others. It has been shown that in health the secretions of these organs are either sterile or nonvirulent. At birth complete sterility exists, but the external genitals are soon contaminated and the *vagina* becomes the seat of an acid-forming bacillus that usually persists throughout life. This organism apparently produces lactic acid, rendering the vaginal mucus an unfavorable medium for the growth of most bacteria and the bacillus is also credited with the ability to directly destroy many pathogenic forms. While such organisms as the pyogenic streptococci may contaminate the skin of the external genitals, it is generally admitted that in health they lose their virulence or disappear as the cervix is approached. Doderlein found that pyogenic organisms experimentally introduced into the vagina disappeared within a few hours; while if an antiseptic douche of sublimate were given, the normal disinfecting action was markedly delayed. The vaginal secretions in pregnancy are also, as a rule, free from pathogenic microorganisms, so that autoinfection from this source rarely or never occurs. Childbirth, dilatation of the cervix, curettage of the endometrium, the introduction of tents and other procedures that bruise or tear the tissues, favor infection by reducing the normal tissues' resistance. Infection is also favored by the presence of foreign bodies. After abortion or miscarriage, clots or portions of dead tissue may be left within the uterus and serve as culture media for many bacteria that may enter. The large blood and lymph sinuses in the pregnant uterus facilitate bacterial invasion. It is important, therefore, that in various operative procedures the gynecologist, obstetrician or midwife reduce traumatic injury to a minimum, guard against the retention of tissues or clot within the uterus and observe scrupulous care that their hands, instruments or solutions do not carry infection. Tents are not to be used except possibly in the modified and relatively aseptic manner suggested by Goelet. The danger of lighting up latent or chronic forms of inflammation in the pelvis by a rough manual examination, the introduction of uterine sound, dilatation of the cervix or similar procedures, is recognized by gynecologists. As a rule such disturbances are to be carefully avoided unless measures against the chronic inflammation are conjoined.

Against a few disease-producing bacteria, notably the *gonococcus*, Doderlein's acid-forming bacillus affords little protection, although even this coccus apparently finds the vaginal secretions the least favorable habitat. In an extensive series of examinations of prostitutes, Laser found the gonococcus most frequently in the urethral and in the cervical canal and rarely in the vagina. It is interesting to note that four-fifths of the 111 cases in which this microorganism was found gave no gross evidence of gonorrhea.

With the normal resisting mechanism inhibited by chemical or mechanical influences invasion by the pyogenic organisms, the *diphtheric bacillus,* certain *molds,* and perhaps by the causal agent of *carcinoma,* may occur. *Tuberculous infection* seems a rare but possible condition, while *syphilitic and chancroidal infection* seem unhindered by the normal secretions; although for their occurrence a slight mechanical lesion may be necessary. The *uterine* secretion is normally alkaline and the *fallopian tubes* and the *endometrium* lined by cells having cilia that wave toward the cervix. The cervix normally contains a plug of mucus that seems to be unfavorable to bacterial growth. The studies of various observers unite in demonstrating that the uterine cavity in health contains no bacteria. Except the gonococcus, few bacteria invade the uterine cavity from below, without mechanical injury.

Irritating factors apparently may render a chronic gonorrhea acute, and Wertheim found that an acute infection may occur from reinoculation of gonococci, despite the existence of the chronic infection.

The *smegma bacillus,* frequently found on the external genitals of both sexes, seems to be free from pathogenic action. It is easily mistaken for the tubercle bacillus, which it closely resembles in form and reaction to stains.

The *male urethra* is probably normally free from bacteria, except within a short distance from the meatus.

Prophylaxis.

This is chiefly embodied in the inculcation of higher morals in a community, in the practice of aseptic midwifery and the avoidance of "meddlesome" gynecology. Venereal infections and those resulting from criminal interruptions of pregnancy are noteworthy. These evils should be more fully exploited in their civic, economic, pathologic and moral relations. No nation is sufficiently strong to bear their extensive practice without grave results.

THE GENERAL RESULT OF BACTERIAL ACTION.

The varying results that follow the entrance of pathogenic organisms into the body are expressions of the alteration or arrest of the normal cellular activities, and are produced by chemical compounds liberated by the invading cells. These toxic compounds may have (1) a *local* action producing changes, chiefly in the immediate vicinity of the bacteria, probably because the substances are here most concentrated; (2) the toxic action may be *diffuse,* producing widespread functional or structural alterations in the body, or (3) the toxic action may be *specific,* picking out certain susceptible cell groups; it may be in areas remote from the site of the bacteria. *Local activities* are characterized by chemotactic, hyperplastic or degenerative or necrotic changes in the vicinity of the microorganisms. These conditions are usually associated, although one is predominant.

If the most marked action be chemotactic, leucocytes are attracted about the bacteria (leucocytic or round-cell infiltration) and if there be an associated local liquefaction of tissue, a circumscribed cavity containing leucocyte laden liquid results, that is termed an *abscess.* Should this process occur in a more diffuse manner in the subcutaneous tissue, the process is called *cellulitis* or *phlegmon.* By the rupture of an abscess or phlegmon through the adjacent surfaces, bacterial channels open at one end (*sinuses*) or at both ends (*fistulæ*) may be formed; or, if there be destruction of the surface layer, with superficial loss of substance, an *ulcer* is formed. Chemotactic forms of inflammation occurring in serous cavities are termed *empyemas.*

Upon mucous surfaces chemotactic organisms cause *purulent catarrhs.* Other bacteria, as the diphtheria bacillus produce superficial exudation and necrosis of mucous surfaces—*pseudo membranes.* When injected under the skin of animals certain organisms as *bacillus anthrosis* cause an exudation of serum—*inflammatory edema.* Other bacteria, as *bacillus aerogenes capsulatus* are gas-forming, so that a *gaseous edema* results. The tubercle bacillus is responsible for a local *coagulation necrosis* that is apt to be followed by caseation.

Diffuse Results in Bacterial Action.

Widespread functional or structural changes may result from the absorption and diffusion of bacteria toxins throughout the body. *Functional changes* are expressed by exalted, depressed or perverted metabolism. Fevers, rigors, convulsions, delirium and coma are clinical expressions of such abnormalities of function. The *structural changes* usually are degenerative and may be characterized by *parenchymatous* degeneration, as occurs in yellow or typhus fevers; *fatty degeneration* as occurs in yellow fever; *amyloid changes* as occurs in chronic tuberculosis, syphilis and leukemia; hyaline or other degenerative change. At times the condition is regenerative and leads to diffuse tissue overgrowths or *hyperplasias.* When pathogenic bacteria show their chief activities in the circulation of the blood, the condition is termed *septicemia.* Abnormalities characterized by the circulation of toxins are called *toxinemias* and the designation *sapremia* has been applied to those diseases, conditions in which products of putrefaction are supposed to circulate within the blood.

The Specific Results of Bacterial Action.

The circulation of toxins may chiefly affect certain susceptible cell-groups leading to specific structural alterations, or to abnormalities in function. Thus, in tetanus there is a special stimulation followed by exhaustion of motor cells in the central nervous system. In diphtheria there may be, from the specific action of the bacterial toxin, degenerative changes in nerve centres leading to various palsies. Many toxins have a specific action upon theromogenic centres in the medulla. As a result of other infections, there may be an overgrowth of certain special tissue throughout the body. This may be the cause of the widespread lymphadenoid hyperplasia in typhoid fever, leukemia and other diseases, and the generalized increase of the fibroconnective tissue in various organs, the products of which lead to the various scleroses or cirrhoses.

Destruction and Elimination of Microorganisms by the Body.

Within the body bacteria usually first *enter* the lymphatic channels and are carried to the neighboring lymph-glands. Here they may be *destroyed* by the *bacteriolytic* action of the cells or may break through the lymphatic barriers and invade the blood. Within the blood they must contend against the *germicidal* activities of the plasma, the *phagocytic* action of the leucocytes, and the bacteriolytic properties of both the white and red corpuscles. Should they successfully resist these various agents, there remain certain organs containing cells having well-marked bactericidal properties. Of especial importance is the *liver.* If suspensions of bacteria be introduced into the portal vein, many organisms otherwise virulent, may be overcome by the hepatic cells, so that the blood leaving the liver will be found to contain either no bacteria or bacteria much reduced in virulence. This action has been shown to be well marked against the bacillus of anthrax, *Streptococcus aureus* and *Oidium albicans.* In general, the bactericidal power of the *lungs* seems to be much less than that of the liver; yet against *Streptococcus pyogenes* the lungs show a well-marked protection, while the liver has but little. Adami believes that in health a certain number of bacteria are taken up from the alimentary canal by leucocytes and carried into the lymphatic glands or the venules of the portal system. In the lymphatic glands of the liver they are destroyed by the leucocytes or by the endothelial cells. Should any bacteria enter the systemic circulation through the liver or the thoracic duct, the kidneys and perhaps other organs tend to remove them. There may exist, therefore, a condition of latent microbism or latent infection, and this may be accentuated, if there be an excess of bacteria in the intestines, into a condition of subinfection associated with a chronic inflammatory disturbance in the lymph-glands, liver, kidneys and other organs. Such a condition may be the cause of forms of hepatic cirrhosis. The pigmentation (hemochromatosis) of the liver-cells, lymph-glands, and abdominal wall, Adami attributes to the multitude of disintegrating bacteria deposited in the cells. A similar condition of the liver has been found in pernicious anemia, and as this is associated with a chronic inflammatory condition in the upper digestive tract, it is supposed to be due to the passing into the portal blood of excessive numbers of colon or allied bacilli that subsequently take up iron containing pigment from destroyed red corpuscles.

It is believed that the *kidneys* are nearly equal to the liver in bactericidal ability, while the *brain* seems to possess but little. Although not experimentally demonstrated, the action of the *red bone-marrow* may be very important, and may explain why injuries to bones in the young apparently determine the localization of tuberculosis.

Bacteria seem to be *eliminated* by the usual emunctories, especially the skin, the intestinal tract and the kidneys. In health, the mammary glands are apparently not an exit for the bacteria in the blood, but in severe or long-continued illness the experiments of Balch, Weleminsky and others indicate that they may thus be eliminated. As is elsewhere mentioned, tubercle bacilli have repeatedly been found in the milk from tuberculous cows free from disease of the udder. Clinical observations indicate that a similar elimination may occur in women. Mothers with tuberculosis, therefore, should not nurse their children.

Bacteria may remain for long periods of time within the body after the subsidence of infection. This is exampled in the persistence of diphtheria bacilli in the throat and nose after diphtheria, typhoid bacilli in the intestines, gall-bladder and urinary tract after enteric fever, and tubercle bacilli in old caseous nodules.

CHAPTER X.

THE DIFFUSION OF PARASITES BY ANIMALS.

The development, reproduction and dissemination of many pathogenic organisms depend chiefly upon certain animals, in or on whose bodies they undergo stages of evolution, multiply, or are merely carried from place to place. Nearly any type of animal, from the lowly organized ameba to the highly specialized man, may be an active factor in the spread of disease.

The animal concerned may be (1) healthy and act simply as a conveyor of the materies morbi; (2) it may suffer from a disease similar to that which it spreads, or (3) from a different disease, the result of a different stage in the life-history of the same parasite. Thus, the healthy nurse may carry virulent bacilli of diphtheria in her throat; the careless accoucheur, the streptococcus of erysipelas upon his hands; tuberculosis may be transmitted from the consumptive, and smallpox from the variolous patient; while the cysticerous disease of the hog's muscle causes tapeworm in the human intestine and the blasts of the mosquito become malarial parasites in name.

The animal in which the parasite acquires its highest development is termed the *definitive host;* the animal in which it undergoes the lower stages of development is the *intermediate host.* For certain parasites man acts as the definitive host; for others, as the intermediate host. For example, the adult forms of the beef, pork and fish tapeworms are found in man; the adult form of the dog tapeworm in the dog, while the adult form of the malarial parasite occurs in the mosquito. Rarely, as in the case of the pork tapeworm, man may harbor either the adult or the embryo parasite.

At times, several animals play a part in disseminating disease, or an animal may spread an infection through his progeny. A rat may be infected by bubonic plague from contaminated soil; the cat that kills the rat may carry contaminated fleas from the rodent to man. The parasite of Texas cattle fever is taken from cattle by ticks, that transmit it to their progeny, and in turn the young ticks inoculate healthy cattle.

Animals may transmit parasites to man by *simple contact* by *polluting food, water* or *air,* or by *inoculation* through the bites, punctures or scratches that they produce. Parasites may also gain entrance to the body by the ingestion of diseased or contaminated animal food.

PROTOZOA.

Of the lowest form of animal life, the *protozoa,* but little is known as to their relation to the transmission of parasitic microorganisms. It is known, however, that amebæ frequently take bacteria into their protoplasm, and it is not probable that future investigations will demonstrate that protozoa play an important rôle in the life-history and dissemination of certain parasites.

MOLLUSCA.

There is strong evidence that contaminated *oysters* have, in a number of instances, been responsible for epidemics of typhoid fever and perhaps of Asiatic cholera. In every investigated case the oysters were exposed to sewage.

Chantemesse has shown that oysters exposed for twenty-four hours in salt water, contaminated by *typhoid* dejections or cultures, and kept unopened for a day after removal, will still yield the organisms of the disease. Boyce believes that typhoid bacilli do not occur in the tissues of the oyster, and that they disappear in from one to seven days after being placed in pure sea-water. Foote, however, says that they multiply in the tissues of the bivalve during the first two weeks, and although they then diminish, may still be found after thirty days. The *cholera* organism was found by Klein in oysters four days after their removal from water previously contaminated; although De Giaxa found that this organism was destroyed in from four to thirty-six hours. The bacillus of *anthrax, Staphylococcus aureus, Proteus vulgaris, pneumococcus,* and other pathogenic organisms have been found active in oysters despite several weeks' exposure to sea-water.

Certain snails appear to be the intermediate hosts of worms parasitic in man. Such is supposed to be the case with the formidable lung fluke *Paragonimus Westermanii.* The guinea worm is believed to undergo an intermediate existence in a small fresh water crustacean—cyclops quadricornis.

As oysters are usually contaminated by polluted water, the *location of oyster-beds* is of extreme importance. The self-purification of rivers may be considerably modified by the influence of the sea into which they flow.

Prophylaxis.

The beds should be so planned that they are not exposed to sewage, either directly by the action of currents or indirectly as by the reflux at flood tide. If the source of pollution cannot be suppressed the bed must be removed. If oysters are removed from the sea to bays, rivers or lakes for purposes of "fattening" it should be ascertained that these bodies of water are free from pollution. Apparently through neglect of this precaution, an epidemic of typhoid fever occurred at Wesleyan University in 1894. Klein believes that oysters from polluted water may be rendered safe by placing them for 16 days in pure sea-water.

ARTHROPODA.

Insecta.

Of the arthropods, the *insects* are the most important disseminators of disease.

The idea that various insects may transmit disease has been suggested frequently in the past. Italians have long considered malaria as due to mosquitoes, while certain savage tribes in Africa retire to the mountain heights at night, or protect themselves from gnats by smudges or by anointing themselves with certain oils, in order to ward off the fevers they believe to be conveyed through the agency of these pests. Many years ago attention was also called to the possibility of excluding the "miasm" of malaria from houses by screening the entering air. Sydenham says that when insects, especially house-flies, swarm in summer, there will probably be an unhealthful autumn. Montfils, in 1877, wrote that anthrax might result from fly bites. Many similar observations have been made by others, but it is only within very recent years that indisputable proof has been collected of the activity of insects in the diffusion of disease among animals and men. The paper by Nuttall, of 1899, was a masterly review of the subject, and its facts have here been freely employed.

Insects may (1) *mechanically carry* parasites; may (2) *inoculate* them by biting or stinging, or may (3) serve as *intermediate* or definitive hosts. These three means of disease transmission have been positively demonstrated by clinical and laboratory experimentation, for at least a number of diseases. Insects probably have an important rôle in the transmission of other diseases, as yet little understood.

Insects as Carriers.

Many experiments have shown that flies, fleas, roaches, bedbugs, and other insects, in walking over infected surfaces pick up bacteria upon their feet, legs, wings, bodies and other parts, and that they may transmit these organisms for considerable distances, contaminating distant articles with which they come in contact. With certain microorganisms it has been found that the insect may still transmit the living parasite after a period of several days. Not only may the insect carry organisms upon the outside of its body, but it may ingest large numbers of bacteria, or of the smaller animal parasites or their ova, and later deposit them in its dejections at perhaps a very remote place. The numbers of organisms found in the dejections, in certain instances, have even suggested that the bacteria undergo multiplication in the insect's body, but this has not been proved. More often it seems that the parasite undergoes degenerative changes in the intestinal canal of its host, so that if it be not deposited with the dejecta within a few hours, or at most a few days, its death occurs. This has been observed especially in connection with the *anthrax bacillus,* but it probably does not hold true for all bacteria. Instead of being discharged from the body, the microorganisms may be liberated by the death and disintegration of the insect.

By one of these methods of transmission, the parasites are deposited upon the surface or within the orifices of the body, in wounds, in drinking-water or upon food. In certain foods especially milk and meat, bacteria find an excellent culture medium in which they greatly multiply, and in some instances may also increase in virulence. Thus, extensive infection may result from a single milk route. Not only may the small vegetable microorganism thus be carried, but also larger particles, including certain *animal parasites* and their ova.

Taenia cucumerina, a tapeworm commonly found in the dog, but occasionally in man, undergoes a larval stage in fleas and dog-lice, and these insects, when swallowed by a warm-blooded animal, have caused tapeworm infection. Various forms of tapeworm, chiefly those found in the lower animals, have been shown to undergo an intermediate stage in beetles, flies, caterpillars, butterflies, as well as in certain worms and crustacea. It has also been shown that common flies and other insects may ingest the eggs of various worms, parasitic to man, and may deposit them later in their dejecta, as has been demonstrated by Grassi in the case of the pin-worm (*Oxyuris vermicularis*), porkworm (*Taenia solium*), and whip-worm (*Trichocephalus dispar*), and by Stiles in regard to the common round-worm (Ascaris lumbricoides).

Allen J. Smith has recently found in the intestines of cockroaches an ameba closely resembling that causing tropical dysentery.

Dewevre found that in 50 per cent. of children experimented upon, *impetigo* could be carried from the affected to the well, by the simple transference of *lice* (pediculi). In one instance, lice were taken from a well child and placed upon a child with the disease, and after twenty minutes were replaced, with the result that the healthy child acquired the affection.

Celli, Nuttall, and others have shown that the microorganisms of *anthrax, cholera, typhoid fever* and *tuberculosis* may be carried by flies, fleas and other insects, and may still retain their virulence after passing through the insect's intestine. These observations have a special importance in connection with typhoid fever and cholera.

The experiments of Simmond, Neffleman and Macrae show that flies are able to infect milk with the *spirillum of cholera,* for at least one-and-a-half or two hours after they have been in contact with contaminated substances. Macrae's experiments were particularly interesting. Exposing boiled milk in different parts of the jail at Gaya, India, he found that on the male side of the jail the milk became infected by the cholera microorganism, while similar infection was not found upon the female side. These two departments of the jail were separated by a high wall, and cases of cholera existed on the male side only. The jail swarmed with flies. Buchanan describes a jail epidemic in Burdwan, India, in June, 1896. Outside this prison there were huts where cholera prevailed. At a certain time a strong wind blew numbers of flies from the side where these huts lay into the prison inclosure, where they settled upon the food of a part of the prisoners. Cholera appeared in the jail but only affected those prisoners fed nearest the huts.

The study of a large number of cases of *typhoid fever* in the American camps during the Spanish-American War indicates that flies, which were shown to be constantly flying from improperly guarded latrines to the mess tents, were the chief cause of the widespread infection.

Flies caught in rooms inhabited by patients suffering with *tuberculosis* have been repeatedly found to contain in their intestines and excreta tubercle bacilli of sufficient virulence to cause the death of *guinea-pigs.*

Flies have also been credited with the dissemination of leprosy, but concerning a disease of such insidious onset the proof is difficult.

Certain forms of *purulent conjunctivitis—Egyptian ophthalmia* and *"Florida sore-eye"*—bear evidence of being disseminated by flies, which are attracted by the discharges, and may readily carry the infectious material on their proboscides and legs, from diseased to healthy eyes. The *Hippelates flies,* occurring in enormous numbers in the southern part of the United States, are especially apt to dart into wounds, the eyes, the nose, and other moist parts of the body, and probably are important carriers of contagion.

Infection of wounds may occur through the agency of flies that fall into the solutions or alight upon the instruments used, or upon the wound itself. Although it is difficult, clinically, to demonstrate infection by this means, there is abundant experimental evidence to show that it is not only possible, but ofttimes probable. Infectious organisms deposited upon broken surfaces of the body may later gain entrance through abrasions produced by *scratching.* In this way infections may result through the skin, although the person has not been bitten by an insect.

Howard has undertaken a comprehensive work to determine not only the importance of flies as disseminators of typhoid fever, but also to determine precisely the *species of flies* that feed or oviposit upon exposed human feces, and how many of these are attracted to human habitations. During 1899 and 1900, 23,087 flies were caught in and around human dwellings, examined and classified. Of these, 98.8 per cent. were the common Musca domestica; others of importance were the *stable-fly* (*Muscina stabulans*), the *little house-fly* (*Homalomyia canicularis*), and the *fruit-fly* (*Drosophila ampelophila*)—all of which were found breeding in human feces. While the common house-fly prefers horse manure as a breeding-place, yet in army camps and country places where the box privy nuisance is still tolerated, they will breed in human excrement in vast numbers, and may be attracted to it without oviposition.

The Inoculation of Pathogenic Organisms Through the Bites of Insects.

From the conclusive evidence that flies and other insects may take into their proboscides living parasites when feeding upon infectious material, it would seem possible that such insects as *biting flies* (Stomyxes, Tabanus, Hemotopota Simulium), *fleas, bedbugs, chigoes,* as well as *spiders* (arachnids) and *centipedes* (myriapods), could, under suitable conditions, produce infection. As yet there is little indubitable experimental proof, but many clinical instances have been recorded in which infection seemed to originate from the insect's bite. Anthrax has repeatedly been attributed to the bites of flies that have previously feasted on the discharges or carcasses of animals affected with splenic fever. Erysipelatous, phagadenic, and carbuncular inflammations have also been ascribed to the bites of insects.

Joly says that it is a common belief in Guadeloupe that glanders is transmitted by flies. Most of the facts submitted to prove infection from the bites of insects are suggestive rather than positive, and although the proboscis of the insect may teem with bacteria, the current during the blood-sucking would tend to carry the parasite away from the body of the victim. The physiologic mechanism of the insect's bite, however, is not so fully understood as to render this conclusion absolute. Many biting insects discharge secretions into wounds and it would seem possible that by this means certain parasites might be washed from the proboscis into the puncture. This is apparently proved in the case of tsetse-fly disease, although Nuttall, in 1898, permitted bedbugs to bite animals dead or dying of anthrax, plague, chicken cholera, and mouse septicemia, and then transferred them to healthy animals that were repeatedly bitten, but in no instance became infected. Bedbugs were also permitted to bite mice through areas of skin on which the spleen from the body of a mouse that had died of anthrax had been rubbed, yet no infection followed. Similar negative results were also obtained from a few experiments made with fleas. In view of these experiments, Nuttall concludes that infection from the bite of a bug does not occur, or at least is exceptional. That infection might occur were the bug crushed while in the process of biting, or the bitten area afterward scratched, is admitted. Joly, in 1898, working with anthrax, obtained similar negative results.

It should be remembered, however, that these experiments are too limited to prove a general negative. They indicate that the ability of biting insects to inoculate disease is not an universal one, but is at most restricted to certain species, and depends perhaps, also, upon the association of special, favoring conditions, such as a particular length of time after contamination and other environmental factors.

In proof of this, observations on the tsetse-fly disease (Nagana) may be cited. Nagana is due to a flagellate microorganism and is endemic, in certain wild animals, especially Ungulata, of Africa. The experiments of Bruce and others prove conclusively that the tsetse-fly, comprising several species of Glossina, carries the parasite from infected wild animals and in biting inoculates such domestic animals as the horse, mule, donkey and cat. Although the bites are painful, they are not infectious to man. It seems that other flies are unable to convey this disease, and for successful inoculation it is also essential that the fly should bite the healthy animal soon after having been on the diseased animal. If the glossinæ are kept hungry for a few days, they then fail to convey the disease. This indicates that the fly acts simply as a carrier and inoculator, and is not an intermediate host of the parasite. The disease may also be conveyed by direct inoculation of blood from the diseased animal. *Trypanosoma* infection of rats seems to be consummated by the inoculation of the parasites by the bites of contaminated fleas.

It will be observed that these, and other parasites to be later mentioned, that are positively known to be inoculated by the bites of insects, are animal parasites and not bacteria; yet the possibility of inoculation of the vegetable parasites in this manner should be considered, and, until it is positively disproved, precautionary measures should be taken to prevent its consummation.

Insects as Intermediate Hosts.

It has been demonstrated beyond cavil that certain varieties of *mosquitoes* act as intermediate hosts for *malaria, yellow fever* and *filariasis.* In each of these diseases the parasite is removed with the blood of an infected person and undergoes a certain developmental cycle in the body of the mosquito, after which the parasite may be inoculated into the body of the next susceptible person bitten. The evidence in proof of this mode of conveyance by the mosquito is conclusive. The experiments, particularly in relation with yellow fever and malaria are striking. Grassi protected during the malarious season, 10 houses containing railway employees and their families—numbering in all 104 persons, including 33 children under ten years of age—in a very malarious district on a plain of Cappaceo, Italy. The protection consisted merely in adopting precautions against mosquito bites, by properly screening houses, into which the occupants were directed to retire before sundown. Despite the prevalence of malaria in the neighborhood, only 3 of the 104 persons were infected. During the malarious season of 1900, Drs. Sambon and Low, of the London School of Tropical Medicine, lived in a very paludous part of the Roman Campagna, in a specially constructed and carefully screened house. No quinine was taken, and no health precautions observed beyond retiring within the house from sundown until daylight the following morning. Despite the general prevalence of the fever in the surrounding country, and although the experimenters exposed themselves to the night air and to the wet and cold of the rainy season, their health remained perfect. About the same time mosquitoes that had bitten a patient suffering with malaria in Rome were sent to Liverpool, and permitted to bite a son of Dr. Manson, who had never been in a malarious country since he was a child. These mosquito bites were promptly followed by a well-marked infection of the double tertian type. Many other experiments have likewise indicated the transmission of malaria by Culicidæ, and it remains to be demonstrated that malaria is contracted in any other way—except experimentally, when blood is transferred directly from the sick to the well.

The recent experiments of Drs. Reed, Carroll, Agramonte and Lazear in relation to *yellow fever* are, if anything, more striking. These observers repeatedly conveyed the infection of yellow fever from the ill to the well through the bites of certain mosquitoes. The sacrifice of Dr. Lazear's life marks the devotion and zeal of these experimenters. It was found that twelve days were required from the time that the mosquito bit the infected person before its bite could transmit the disease, and that after this period it maintained its ability to infect the well for at least fifty-nine days. To carry out the experiments more thoroughly, two buildings were erected. One, known as the infected mosquito building, was divided into two rooms by a wire screen partition extending from the floor to the ceiling. The door and windows were screened, but so placed as to give thorough ventilation. All articles introduced within the building were previously carefully disinfected by steam. In the large room of this building mosquitos that had previously been contaminated by biting yellow fever patients were placed, and persons who were not immune to yellow fever entered both rooms. In the room free from mosquitos the experimenters remained in perfect health, while six out of seven persons bitten by infected mosquitoes promptly contracted yellow fever. The second building erected was a small frame house with a capacity of 2,800 cubic feet. It was tightly sealed and battened, provided with small windows to prevent thorough ventilation, and with wooden shutters to avoid the disinfecting action of sunlight. The house was carefully screened to prevent the entrance of mosquitoes. The average temperature in the house was 76.2° F., and care was taken to keep the atmosphere humid. On November 30, 1900, three large boxes filled with sheets, pillow cases, and blankets that had been used on the bodies and beds of patients suffering from yellow fever, and were soiled with their discharges, were placed in the room. This soiled linen was not disinfected and was used in preparing the beds upon which nonimmune persons slept. Later a fourth box of clothing and bedding was added, this being so vilely soiled with the bloody stools of a fatal case of yellow fever that for a time it was difficult to remain in the house after the box had been opened. Two nonimmunes occupied the beds from December 21st to January 10, 1901, every night wearing the garments worn by yellow fever patients during their entire attacks, and making exclusive use of their much-soiled bed linen. Each night this linen was shaken to diffuse adhering particles in the air and each morning packed away in the cases. At the end of twenty-one nights, two other nonimmune persons occupied the same beds for twenty days more. In all, seven nonimmune persons were exposed in this building during the period of sixty-three days, yet all remained in perfect health. In these experiments the greatest care was taken to avoid anything that would militate against the accuracy of the results, and the evidence is conclusive that a mosquito (*Stegomyia fasciata*) serves as the intermediate host for the parasite of yellow fever. The clinical application of the results of these experiments is corroborative. Thus, yellow fever was endemic in Havana and persisted despite the approved measures of sanitation practiced after the occupation by United

States troops. After the adoption of measures to prevent the conveyance of infection by Stegomyia, the disease was eradicated for the first time in the known history of the city. Considered in conjunction with the mosquito's ability to live and retain the virus for several months, to hibernate during cold weather, and to be transmitted in various vehicles and on shipboard, many features relating to the development of epidemics of yellow fever are for the first time satisfactorily explained.

Manson was the first to show that the mosquito acts as the intermediate host of the parasite of *elephantiasis.* In this disease the adult worm (Filaria sanguinis hominis) that remains in the lymph vessels gives birth to broods of embryos that are disseminated in the lymph stream and finally enter the blood. They occur in abundance in the blood when the patient is asleep and apparently retire to the lymphatics during his hours of activity. The mosquito, in biting, seems to entangle these embryos in its proboscis, and to draw them into its stomach, where the embryos lose their hyaline envelopes, penetrate the gastric walls, and enter the muscles of the thorax. Here they remain until the seventeenth day, when they collect in the connective tissue of the anterior part of the thorax, and by the twentieth day are found to have penetrated the neck, the back and the head of the insect. It seems evident that, if the mosquito bites after this time, the filaria that have entered the veno-salivary duct may be introduced into the tissues of the individual bitten. It is supposed that in the skin the embryos reach adult development, then burrow, enter the lymphatics, and give rise to broods of embryos, thus completing the life-cycle.

Each of these three diseases is transmitted by its particular mosquito: malaria by certain *Anopheles,* yellow fever by *Stegomyia fasciata,* and the filaria by a Culex, and possibly by *Anopheles.* Experiments indicate that Anopheles will not transmit yellow fever, nor Culex, malaria. Recently Graham has apparently shown that *dengue* likewise depends upon a hematozoon carried and inoculated by mosquitoes, and the finding of immature flukes in a variety of culex is also reported.

In 1890 Grassi found that the embryo of *Filaria recondita* (Hematozoon of Lewis), which closely resembles *Filaria sanguinis hominis,* undergoes a metamorphosis in the dog, cat, and man-fleas (Pulex irritans) yet he failed to infect animals from these fleas.

In the case of *Texas fever* of cattle, Theobald Smith has shown a remarkable phase, in the role of cattle ticks as intermediate hosts. The casual parasite of this disease is a very minute hematozoon (Pyrosoma bigemium). The cattle tick (Boophilus bovis), having filled with blood, drops from the animal, and a few days later lays her eggs. After twenty to forty-five days, the embryos escape from the egg and attach themselves to cattle. Two weeks later the young tick is sexually mature, becomes fertilized in twenty-one to twenty-three days, and it, also, drops to the ground and in turn lays eggs. A tick generation has an age, throughout, of from forty-one to sixty-eight days. The experiments of Smith and Kilburn, which have since been confirmed by Koch, show that the embryos developed from eggs laid by a tick that had fallen from a diseased animal are capable of infecting other animals. There is here, therefore, a remarkable transmission of the parasite of the disease from the parent tick to its ovum. There is no evidence that this occurs in the mosquitoes that serve as hosts for the parasite of yellow fever or malaria.

Vicente believes that a louse (Aspidiotous nerii) infesting the oleander to be a vehicle for the transmission of malaria. It is claimed that the hematozoon has been found in these lice but this observation requires confirmation.

It is yet to be determined in how many diseases insects serve as intermediate hosts, or the number of different hosts that a single pathogenic organism may have.

RODENTA.

Rats and mice may suffer from a variety of parasitic skin diseases transferable to man, including *scabies* and forms of *tinea*. Their flesh may be infested by trichina, sarcosporidia or other parasites. Rats also are very susceptible to *bubonic plague*. These diseases may reach man through direct contact with the rodent or by the intermediate agency of fleas, cats, dogs or contaminated utensils or articles of food.

Of especial importance is the relation of rats to the spread of plague. Rats may contract plague from infected soil, from contaminated fleas, or from eating portions of the bodies of those dead of the disease. From the rat, the bacillus may be carried to man by fleas. Loir concluded that the immunity enjoyed by oil-carriers in plague epidemics was a result of the flea's aversion to oil. It is possible that in rather rare instances the infected rodents may directly inoculate man through their bite; thus, Bell relates the case of an adult Chinaman who developed plague three days after having been bitten in the thumb by a rat.

Rats are said to be so susceptible to plague that they may be infected by merely touching their nasal mucosa with a smooth glass rod that has previously been touched to a culture of the Bacillus pestis. The death of many rats in a neighborhood or on shipboard may be the first evidence of the presence of plague. Thus, in Santos and other cities the appearance of plague was preceded by a large mortality among the rats.

DOMESTIC ANIMALS.

Parasites may be conveyed from domestic animals to man in one of the following ways:

1. *Direct Contact.*—Many parasitic *skin diseases* occur in the dog, cat, and horse, and are transmissible by contact to man. These include forms of ringworm or tinea, caused by Trichophyton tonsurans; *favus,* produced by Achorion schoenleinii; and *pityriasis versicolor,* resulting from the action of Microsporon furfur. *Scabies* has been observed upon the nose of dogs. If the roundworm of the dog (Ascaris suilla) be, as some suppose, identical with Ascaris lumbricoides, the discharges from the dog may be a source of this infection in man, as they are known to be the source of infection by Taenia echinococcus.

2. *Inoculation.*—The most serious disease inoculated by bites of domestic animals is *rabies.* This disease occurs most frequently in dogs, but may affect cats, horses, cows and other domestic as well as wild animals. The infectious principle is present in the saliva of the rabid animal. Inoculation may result from the entrance to the body of fluids or discharges from animals suffering from *tetanus, anthrax, glanders, actinomycosis* or *foot-and-mouth disease.* In December,

1901, a number of deaths occurred in St. Louis from *tetanus* following the subcutaneous injection of diphtheria antitoxin secured from a horse afterward found to be affected by this disease. The prevalence of tetanus after vaccination during the winter of 1901-'02 in a number of North American cities has suggested that the infection may be carried in vaccine matter. Suggestive evidence is found in the statistical studies of Mc Farland and the reported finding of tetanus bacilli in vaccine. Tetanus bacilli are frequently found about stables and cattle, although less susceptible than horses, are not immune. It is obvious that the production of antitoxins and vaccine should be under expert bacteriologic control. Operative tetanus has been attributed to the use of kangaroo-tendon, in reality horse-tendon, and to the injection of solutions of contaminated gelatin. Punctures by splinters, nails or other objects about stables are often followed by lockjaw, these objects apparently being contaminated by the dejections of horses.

3. *Aerial Infection.*—In coughing and snorting, horses suffering from *glanders* throw into the air liquid particles laden with Bacillus mallei. These particles may be inhaled by persons or by lower animals, may fall upon wounds, or contaminate various inanimate objects in the immediate neighborhood. In this manner, or by direct contact with the discharges from the nares or from farcybuds, this virulent disease is spread. In a similar manner organisms of *actinomycosis*, *tuberculosis* and *aspergillosis* may be conveyed from cattle to other cattle, or to man. *Psittacosis*, a pulmonary disease of parrots, may likewise be transmitted to the human family, producing a serious pneumonic disorder. From sick parrots imported from South America to France, sev-

enty persons in Paris became ill with psittacosis and thirty-four died.

The evidence that cats, dogs, horses or fowls may contract diphtheria or scarlet fever does not seem conclusive. It is known, however, that dogs, cows and other animals may acquire tuberculosis.

4. *Indirect Infection.*—Parasites may be carried from domestic animals to man by fleas, lice, flies or other insects. The casual agent of many infections may be carried on the fur, feet or in the mouths of healthy animals, especially those serving as pets. As will later be considered, foods of animal derivation are responsible for a number of diseases.

Prophylaxis.—Animals suffering from diseases dangerous in man, such as plague, anthrax, glanders, psittacosis and actinomycosis should promptly be killed, the bodies burned, quicklimed or buried deeply. Animals with advanced tuberculosis should be destroyed, cattle with early lesions and without cough may be segregated and used only for breeding purposes. Rats should be excluded in the presence of contagious disease. Domestic animals suffering from uncinaria or other parasitic worms dangerous to man should be either killed or segregated and treated with thymol or other efficient anthelmintic. Care should be taken that their discharges do not disseminate the parasites. Animals afflicted with vermin, tinea, scabies, or other contagious skin disorders should be treated with an appropriate parasiticide.

CHAPTER XI.

THE DIFFUSION OF PARASITES BY FOOD.

Milk.

In milk at a sufficient temperature most bacteria undergo rapid multiplication. Klein even asserts that the tubercle bacillus increases in virulence when grown in milk. It is, therefore, evident that milk is a most important medium for the transmission of infectious disease. It may be contaminated before or after leaving the cow.

Contamination in the Udder.

From the presence of local disease in the udder various bacteria and purulent products may pass directly into the milk. Stokes in investigating an epidemic of gastro-intestinal disorder in Baltimore found that the thick cream-like layer of the milk used consisted largely of pus. Disease may result from the use of milk from cows infected with anthrax, pleuro pneumonia, rinderpest, foot and mouth diseases, mastitis and other diseases. In a number of infectious diseases of cows it has been shown that the bacteria may be eliminated through the mammary gland.

Tuberculosis.—It is generally admitted that cows showing emaciation, or having diseased udders, in association with tuberculosis, are especially liable to give milk containing tubercle bacilli. The danger from cows free from udder disease and emaciation, and with a stage of tuberculosis only recognizable by the tuberculin test, is less marked but distinct. Ostertag found no tubercle bacilli in the milk of 49 cows reacting to tuberculin but without other symptom of disease. He advises a fortnightly examination of such cows and the weeding out of the emaciated and those with diseased udders, in whose milk he usually found tubercle bacilli. As it is difficult to detect emaciation and udder disease in its early stages, the risk of following out this advice is evident. Upon the other hand, there is little doubt as to the general safety of milk from cows that do not respond to the tuberculin test. Lydia Rabinowitsch found no tubercle bacilli in the mixed milk from large herds of such cattle. In herds guarded by mere clinical observation, virulent tubercle bacilli were found in a number of instances. MacFadyen estimates that 30 per cent. of the cattle in Great Britain are tuberculous. In various tests over the United States from 2.2 to 50 per cent. of the cows were found to react to the tuberculin test. Milk, therefore, should only be taken from cows in good health that do not react to tuberculin. This injunction is based upon the evidence accepted by nearly all bacteriologists but Koch, that tubercle bacilli from cattle are infectious in man. As this important point has been the subject of controversy and much experimentation, the grounds for believing that bovine tubercle bacilli are infectious to man may briefly be given. (1) In nearly all of the lower animals, including hogs and monkeys, the bovine tubercle is more virulent than the avian or human bacillus. (2) Tubercle bacilli from tuberculous human beings may cause extensive disease in cattle as shown by Ravenel. (3) Of children in hospitals using cow's milk as food, not less than one-third of the deaths may occur from tuberculosis and over one-third of these bodies may reveal a primary intestinal infection, as shown by the statistics of Still and others. (4) The relatively greater frequency of pulmonary over intestinal tuberculosis does not prove that the predominant mode of infection was by inhalation. Of four animals that developed extensive tuberculous lesions from eating food containing tubercle bacilli, Ravenel found intestinal lesions in but one. (5) A number of cases have been collected in which the direct tubercular infection of man from the diseased bodies of cattle occurred. Besides this there are a multitude of clinical observations in which tuberculosis seemed to result from the drinking of milk from diseased cows.

In the light of the evidence here briefly summarized, tubercle bacilli from cattle should be dreaded as especially virulent and the greatest care should be taken to prevent their entrance into the body.

Contamination from Handling.

Milk may be contaminated by particles of dirt, manure, epithelial scales or wound secretions from the cow's body, from dust in the air or infectious particles on the hands or clothing of the milker. Ravenel has shown that tuberculous cows may expel bits of mucus containing virulent bacilli when coughing. Similarly, persons with pulmonary or naso-pharyngeal affections may in coughing, sneezing or talking contaminate the milk. Flies and other insects may carry contamination, and polluted water used in washing utensils or added as an adulterant to milk may render the milk infectious. Epidemics of diphtheria, scarlatina, typhoid fever, cholera and other diseases apparently have been caused in one of these ways. Kober in a study of 195 epidemics of typhoid fever traceable to the milk supply, found that the disease was present at the farm or dairy in 148. Of 99 scarlet fever epidemics the malady was present at the special dairy or farm in 68. In 6 instances persons associated with the dairy lodged or visited in houses in which scarlet fever existed. In 17 instances the infection was ascribed to persons handling the milk while suffering with or convalescent from the disease, and in at least 10, to people who acted as nurses while handling the milk. In one case cans had been wiped with contaminated cloth and in two, bottles or cans had been in houses where infection was present. Kober's studies of 36 outbreaks of diphtheria ascribed to polluted milk, showed 13 cases in which the disease existed at the dairy, and three in which employees handled the milk while ill with the disease. Two-hundred and forty-three of these 330 epidemics were recorded by English authors an excess ascribed to the fact that raw milk is usually employed in England and America, while cooked milk is in vogue upon the Continent.

The gastro-intestinal disorders of infants, prevalent during the summer are considered to be gastro-intestinal infections usually derived from milk. The milk in these instances may contain specific microorganisms or be harmful from the enormous number of bacteria present, a result of imperfect refrigeration or lack of precaution in handling the liquid. The milk dispensed in large cities during the summer not infrequently has a bacterial population greater than that of sewage. Thus, it is not unusual to find over 2,000,000 bacteria to each cubic centimeter of milk.

The following table, from the studies of Wm. H. Park, shows the influence of temperature upon the bacterial purity of milk and also the relation of sanitary precautions in collecting milk to its purity. The milk marked No. 1 was collected under best conditions and contained when temperatures and the number of the contained bacteria in each cubic centimeter counted at the end of 24, 48, 96 and 168 hours.

INFLUENCE OF TEMPERATURE UPON THE BACTERIAL PURITY OF MILK.

		After 24 Hours.	After 48 Hours.	After 96 Hours.	After 168 Hours.
23° F.	1	2,400	2,100	1,850	1,400
	2	30,000	27,000	24,000	19,000
46° F.	1	3,100	12,000	1,480,000	
	2	42,000	360,000	12,200,000	
68° F.	1	450,000	25,000,000,000		
	2	4,000,000	250,000,000,000		

That milk from a mixed herd may contain fewer bacteria than that from individual cows is shown in the following table:

BACTERIAL PURITY OF MILK FROM MIXED HERDS AND FROM INDIVIDUAL COWS.—(Park.)

Number of bacteria in each 1 c.c.: A referring to the average number of bacteria from individual cows; B to the average number of bacteria in mixed milk from the entire herd.

	5 Hours After Milking.	24 Hours.	48 Hours.	72 Hours, Not entire.
A.	6,000	1,938	17,816	
B.	4,333	2,766	10,583	329,000

Milk products, such as cream, butter, cheese, ice-cream, and "hokey-pokey," may convey the same germs as those present in the original milk, plus those that may gain access through uncleanly manipulations.

Prophylaxis

The bacterial contamination of milk results from the uncleanly condition of the cow's body, the milker's hands or body, the air, or the containers. To avoid these sources of contamination, manure should be removed promptly, and care be taken that the cow's bedding is clean, and that the udder is cleansed with a clean damp cloth before each milking. The dairymen should be free from tuberculosis or other infectious diseases, nor should they associate with people suffering from infections. The milker's clothes should be clean and their hands well washed before each milking, and milk should not be used to lubricate the teats. They should avoid coughing or sneezing over the milk. No sweeping should be permitted about the time of milking. The use of impervious floors that are kept clean by washing rather than sweeping is advisable. All milk receptacles should be well cleansed and scalded before use, and the milk-pail should have an opening not over six inches in diameter, protected by fine gauze. After collection, the milk should promptly be cooled to at least 46° F., which temperature should not be exceeded. It should not contain over 12,000 bacteria per cubic centimeter in warm weather, or 5,000 in cold weather, and at the end of thirty-six hours the number of bacteria should be less than 50,000 per cubic centimeter; or if the milk has been kept at a temperature not exceeding 40° F., less than the original number of bacteria should be present. If the milk be dispensed in glass jars, these should be sterilized before each filling and not collected, filled and distributed *en route*.

In Philadelphia certified milk is sold at a moderate advance over the usual charges. The purity of this milk is determined through arbitrary monthly inspections, by a committee appointed by the Philadelphia Pediatric Society. Any dairy capable of fulfilling the necessary requirements may supply milk under the certification of the Society. Bacteriologic and sanitary inspections of this character, not only render available a particularly wholesome milk, but they tend to incite dairymen to build better stables, to take greater care of cows and to observe stricter rules in handling milk. Thus, an influence tending to better the milk supply in general is produced. Often, however, and especially if infants be concerned, the consumer cannot depend altogether upon precautions which may be vitiated by the carelessness of a single person among the many engaged in handling milk, and should render the food non-infectious before its use. This may be done by pasteurizing or sterilizing. If pasteurizing is attempted, it should not be carried out in the makeshift ways often recommended, such as those in which bottles of milk are placed in pails of boiling water and the pail and its contents permitted to cool. Such measures are uncertain, and should be replaced by methods or the use of forms of apparatus that are known positively to maintain the temperature of the milk between 70° and 80° C. (158° and 176° F.) for thirty minutes. If such a measure is impracticable, milk should be boiled for five minutes, or sterilized by steam for at least fifteen minutes. That such high temperatures slightly impair the nutritive or digestive qualities of the food by altering the nucleo albumins may be true, yet it is best to insure safety against infection. In the home, careful refrigeration should be continued and all utensils that may come in contact with the milk carefully cleansed. Moreover, infant's food should not be warmed until immediately before use, for fear of favoring bacterial multiplication.

Meat.

Flesh containing encysted animal parasites is termed "measly." From the ingestion of improperly cooked or cured measly pork one may become infected with *trichinæ*, the pork tapeworm (*Tænia solium*), or, rarely, *sarcosporidiæ*;

from beef, beef tapeworm (*Tænia mediocanellata*), anthrax, or tuberculosis. From eating certain European and Asiatic fish, the fish tapeworm (*Bothriocephalus latus*) may be acquired. All these parasites are destroyed by thorough cooking of the meat. The rule adopted in parts of Europe of permitting the flesh of animals with tuberculosis or certain other communicable diseases to be used, provided the lesions are local, should not be followed. The limitation of gross lesions to certain organs of the body does not prove that the causal organism is not diffused through the body. The flesh of animals dead of disease of any character should be condemned as food. In slaughtering and in the after handling of meats contamination by contact with inanimate objects, insects, the larger animals or man, may occur. Cooks, butchers and others that handle meats should be free from tuberculous or other infectious disorder. This applies with particular force should uncooked or underdone meats be used as food.

Vegetables.

Uncooked green vegetables may have animal or vegetable parasites deposited upon them from the soil, in fertilizers, in dust, or by contact with living or dead animals (including insects), or human beings. It is believed that the eggs of the common *round-* and *pin-worms* often gain entrance to the body upon improperly washed celery, lettuce, water-cress, or other greens.

Forms of the *Amoeba coli* may likewise be acquired. This form of infection is especially to be feared when gardens are sprinkled with fresh solutions of fecal matter. Manure from the lower animals may contain parasites pathogenic in man, and insects may deposit parasites upon plants.

Grains and flour may contain the ova of flies or other insects, and if ingested without previous cooking, the larvæ developing within the alimentary canal may produce marked irritation. The presence of the larva of the common *meal beetle* (*Tenebrio obscurans*) in the intestines of a patient of J. J. Welsh was attributed to the use of gluten suppositories. It is supposed that the egg was present in the gluten flour.

Of the *bacteria,* members of the *colon group,* especially the *typhoid* bacillus, seem to be the organisms most frequently transmitted by vegetables. The prevalence of dysentery and other intestinal disorders in China and Japan has been attributed to the extensive use of night soil as a fertilizer.

The State Board of Health of Massachusetts apparently demonstrated that an outbreak of typhoid fever at the State Hospital for the Insane at North Hampton was spread by celery raised upon the premises in beds watered with filtered sewage. The disease occurred only in those who had eaten celery and the avoidance of this vegetable was effective in checking the spread of the infection. Ferre has reported a similar outbreak that occurred in a girl's school at Jurancon, affecting only the boarders and not the day scholars, in which it was found that the vegetable garden from which the school was supplied was watered with the contents of a cess pool. The *tetanus bacillus* may thus be conveyed, but seems to be innocuous when swallowed.

Fruits and other vegetables may be contaminated by handling or by exposure to bacteria-laden dust. Fruit displayed for sale on street stands in the larger cities is a rendezvous for insects of the street; is polished by filthy hands upon filthier cloths or clothing; is often coated by a layer of the dust blown from the pavement that is polluted from horse-droppings and sputum, and otherwise is exposed to soiling. To contemplate the many patrons of these stands who escape disease is but to develop admiration for the high degree of insusceptibility of our genus, and the influence of sunlight, dessication and other natural disinfectants.

Rinsing in cold water or wiping with a damp cloth are untrustworthy methods of cleansing fruits and vegetables that are to be eaten uncooked. So far as possible the outer rind or cuticle should be discarded and not brought in contact with the mouth. It has been suggested that fruits be dipped in an antiseptic solution, such as one of tartaric acid or especially formaldehyde.

A sufficient superficial sterilization of fruits may be consummated by dipping them for from five to ten seconds in boiling water. Even grapes suffer little damage during this procedure.

CHAPTER XII.

THE DIFFUSION OF PARASITES BY SOCIAL INTERCOURSE.

SOCIAL INTERCOURSE.

Fomites.

The diffusion of disease is often attributed to *fomites,* or porous substances capable of retaining virus; including articles of wearing apparel, bed-clothing, fabrics of linen or cotton, leather goods and the like. The possibilities of infection through such contaminated articles has probably been much overrated, and we have little exact experimental evidence showing its precise importance. For example, *yellow fever* was considered, until recently, to be in large measure conveyed by fomites; but the recent experiments at Camp Lazear in Cuba show that this mode of infection is improbable. As a rule, porous substances do not retain living infectious bacteria for any considerable time, as their dryness leads to the death of the organisms. Shoemaker mentions an instance in which a sister acquired gonorrheal ophthalmia by wiping her face with the soiled handkerchief of her brother. Articles that have recently been contaminated by pathogenic discharges may be dangerous, especially when brought in contact with open wounds. By violent agitation, as in sweeping, dusting or beating, infectious particles may be thrown from soiled fabrics into the air and may be injurious if inhaled. Fomites, at present, are thought to be an important means for the transmission of *scarlet fever, small-pox* and *measles.* Numerous instances are on record in which fabrics have apparently retained the virus of scarlet fever for months. It must be admitted, however, that although extremely probable, the evidence is largely clinical and for many diseases is without the proof of rigidly controlled experiment. Observations that seem equally conclusive were brought forward to prove the similar conveyance of yellow fever.

Domestic Articles.

Of the articles used in common by two or more persons, that may serve to diffuse infection we may cite tableware, toys, nipples of feeding bottles, tooth and hair brushes, sponges, lather brushes and razors, manicure instruments, ear spoons, syringes and similar utensils. In toilet rooms and from beds, the *pediculosis pubis* or *corporis* may be acquired. In dining it is important that those suffering from diseases communicable by saliva, such as syphilis, tuberculosis, diphtheria and scarlet fever have an individual tray reserved for their own use and kept apart from the service of other members of the household. Such utensils should be immersed in boiling water each time after they are used. For the cleansing of ordinary tableware, the method of the careful housewife, of thorough washing in hot, very soapy water and rinsing in scalding water, does not require improvement. Mothers having tuberculosis should take great care that articles used by children are not soiled by contact with their mouths or saliva. The practice of wetting the finger with saliva to facilitate the handling of various articles is reprehensible. Tubercle bacilli have been found in the dregs of the communion cup and the glasses and cups provided at public fountains and drinking stands may be contaminated.

Surgical and Dental Instruments.—Improperly disinfected instruments may transmit organisms of *erysipelas,* and *suppurative* processes, of *syphilis, gonorrhea, scarlet fever, diphtheria, tuberculosis* and *actinomycosis.* It is difficult to estimate the frequency of infection by this means. In a number of instances syphilitic and other serious infections have directly been traced to septic instruments used in the filling or extracting of teeth. Physicians have caused serious infection by disregarding the rules of aseptic surgery in the use of scalpels, forceps, urethral, or eustachian catheters, tongue depressors, thermometers and other instruments. Mention may be made of the serious inoculation of the conjunctiva or cornea through the use of instruments contaminated by vaccine. The carelessness or ignorance that permits these infections by physicians is inexcusable and the person responsible is liable to civil action. Instruments are readily sterilized by immersion in boiling water for five or ten minutes. Thermometers may be sterilized by washing and then immersing in a solution of formalin or mercuric chlorid. It is desirable that the surface of the thermometer be smooth, and free from the depressions resulting from graduation or the maker's stamp.

Chiropodists and *manicures* should carefully sterilize their instruments after each use. The spread of sycosis, other skin diseases and more serious infections by *barbers* is easily prevented by the sterilization of razors, brushes, combs and cups after each use, the avoidance of the common sponge, puff-ball or stick of styptic. It is satisfactory to note the establishment of antiseptic barber shops in many parts of the United States.

Mail Matter.—The conveyance of pathogenic organisms by the postal service is evidently rare. The dryness of the paper sent by mail is unfavorable to the perpetuation of bacterial life. It is difficult to prove that cases of reported infection occurred in this way, although instances similar to the following one, related by Gripat, are suggestive: A mother living at Angiers received from her sister-in-law, in a northern city, a letter in which the concluding sentence read, "I am writing, holding upon my knee my little girl, who has just developed measles." The sister-in-law at Angiers also happened to have her daughter upon her knee when she was reading the letter, and the little child seized the envelope, played with it, and carried it to her mouth. The letter was burned at once, but twelve days later the child developed an indubitable measles rash. At this time there was no other case of measles known to be in Angiers.

Letters may be *disinfected* without injury by means of formaldehyde gas, which readily penetrates envelopes. Most efficient is a chamber connected with an intermittently acting vacuum apparatus to facilitate the penetration of the formaldehyde. Dry heat, at a temperature of 160° C. (320° F.) also may be applied. More efficient is dry steam, provided care be taken to expose the mail to hot dry air, immediately following the steam, in order to prevent watery condensation.

Transportation.—The measures adopted to prevent the spread of disease during travel are usually imperfect. In the berths of sleeping-cars and boats one may come in close personal contact with the same utensils and bedding that but a few hours before were used by a consumptive or a victim of other infectious disorder. To prevent repeated use without washing it has been advised that only white blankets be furnished in such public conveyances. Attempts to disinfect sleeping cars with formaldehyde gas have given unsatisfactory experimental results. Exposed woodwork should be carefully washed and the bedding removed and sterilized after each trip; forms of apparatus using steam or formaldehyde being employed for this purpose. In railroad or street-cars vibration tends to keep the air constantly filled with dust from the floor and other parts of the air. If the regulation about spitting is not enforced or if the car be soiled in other ways, it is likely that dry pulverized infectious material will be carried into the air, deposited on, or taken into, the bodies of the occupants of the car. The use in common of lavatories and drinking-cups should be supervised and measures taken to ensure the destruction of vermin. Purulent ophthalmia, tuberculosis, the acute exanthemata infectious, cutaneous disorders, and many other diseases may be acquired in public conveyances.

Commercial Intercourse.—The commercial relations existing between individuals, communities and countries may serve as an important means for the spread of infection. The regulation of the importation, inspection and disinfection of fabrics and food-stuffs is a part of State and municipal hygiene. Of especial importance is the conveyance of anthrax by hair or wool. Coin or paper money, checks, tickets, letters and the like, all may carry infection. Fortunately, textile fabrics, scrip, and coin may be effectually disinfected by formaldehyde or by steam.

Personal Contact.

Personal contact is responsible for many of the infections. A disease may be transmitted from a person who is ill or who has recently had the disease, or, at times, from one who has merely associated with the sick. Thus, *diphtheria* may be communicated from those who have the malady, from convalescents, and by association with apparently healthy members of the household. These healthy individuals may have virulent diphtheria bacilli in their throats and are as dangerous as a patient with diphtheria or a convalescent. It is important, therefore, to make cultures from the throats of all who have been exposed and to isolate, until proved harmless by bacteriologic test, persons in whose throats the Klobs-Löffler bacillus is found. This bacillus may remain for months in the mucous membrane of the nose, pharynx and larynx without any clinical sign of the disease developing.

In the statistics generally quoted, diphtheria bacilli were found in 18.8 per cent. of persons who had been exposed. Kober studied in Flugge's laboratory 128 healthy persons who had been in contact with cases of diphtheria, and 600 who were not known to have been so exposed. Of the former group 8 per cent. were found to have virulent diphtheria bacilli in their mouths or throats. Of the latter group, 15 or 2.5 per cent., showed the presence of the bacilli, as compared with 7 per cent. in other statistics. Further inquiry showed that 10 of the 15 could be considered to have been exposed directly or indirectly, thus reducing the proportion of unexposed individuals who carried the organism in their throats to 0.83 per cent. Besides, in the 15 cases of the second series, the bacilli were non-virulent in 10.

Although we have less definite knowledge in regard to many of the other infectious diseases, such as *scarlet fever, small-pox* and *typhus fever*, the importance of isolating those who have had the disease, for a considerable period after their recovery, and of supervising the personal intercourse of others exposed, is obvious.

A *lesion* of the skin or mucous membrane may or may not be necessary to infection, but, as a rule, favors the invasion of a virus. The *itch mite*, for example, penetrates the unbroken skin, the *gonococcus* invades intact mucous membranes, while inoculation with *vaccinia* or the *syphilitic virus* is favored by local lesions, although often very small and superficial. The chancre of syphilis is chiefly found upon portions of the generative organs most exposed to abrasion during the sexual act; upon the lips it often occurs in the situation of a chronic fissure; upon the hands, at the site of a scratch or abrasion, as evidenced by the not infrequent infection of surgeons and obstetricians in this manner.

Sexual impurity is the chief factor in the spread of a number of the most virulent and widespread diseases. Besides syphilis, gonorrhea, and the chancroidal ulcer, it has been claimed—upon evidence, however, that is not entirely conclusive—that *leprosy, tuberculosis, elephantiasis,* and even *carcinoma* may similarly be conveyed.

No satisfactory method for the municipal *suppression* or *regulation of prostitution* has yet been devised. In the United States no city will tolerate open licensing and inspection of prostitutes. Although European statistics indicate that such methods may diminish the prevalence of venereal disorders, they cannot be entirely efficient, and are open to much criticism, apart from the moral responsibility placed upon the municipality. The infectious elements of syphilis or gonorrhea are with difficulty eradicated from a person involved, and gonorrhea may be transmitted by man or woman years after the original infection has subsided, and despite continued treatment.

The Committee of Seven on the Prophylaxis of Venereal disease in New York City, estimated that there was a venereal morbidity of 225,000 cases in that city alone during 1900. This committee advised educational measures, the treatment of the diseased in hospitals, the raising of the age of consent and the rigid prevention of proxenetism.

The one reliable defense against venereal infections is sexual purity, and to this end a higher moral education of the race is of first importance.

CHAPTER XIII.

THE INHIBITION OF THE FACTORS IN DISEASE.

DISINFECTION.

The *natural defenses* of the body include provisions to exclude microorganisms, to inhibit their growth, and to destroy them. That these natural defenses ofttimes fail is evident from the prevalence of infectious diseases, and for this reason the application of *artificial defenses* becomes of great importance.

These latter likewise include measures for the prevention of infection by: (1) the exclusion of living pathogenic organisms, or methods of *asepsis;* (2) the inhibition of the activities of pathogenic organisms, or the application of *antiseptics;* (3) the absolute destruction of all pathogenic organisms, or measures of *disinfection.*

A medium unfavorable to the growth and activities of pathogenic organisms is called an *antiseptic,* while one destroying them is termed a *germicide,* or, if the organism be bacteria, a *bactericide.* This destruction of agents capable of causing infection is often termed *sterilization,* while any substance that is or has been rendered incapable of producing infection is said to be *aseptic* or *sterile.* It should be observed that these terms have somewhat different meanings to the bacteriologist and to the sanitarian. The work of the former may be influenced by many of the lower fungi irrespective of their action upon the animal body, while the latter considers microorganisms only as to their ability to incite disease. Thus, to the bacteriologist the sterile article is one free from all living organisms, pathogenic or nonpathogenic, while the sanitarian deems the article sterile even though it may be contaminated by many living bacteria, provided none of these bacteria is pathogenic. To the bacteriologist an antiseptic usually means the agent that prevents the growth of bacteria, while a disinfectant is one that destroys the ability of the organism to grow. From our view-point, the antiseptic is an agent inhibiting the spread of infection, while a disinfectant is one that precludes the possibility of infection, irrespective of the viability of the bacteria. Thus, by exposing anthrax bacilli (free from spores) to a temperature of 55° C. (131° F.) for ten minutes the organisms may be so reduced in virulence as no longer to be able to excite disease, yet they grow as freely as they did before the heat was applied. While such an exposure is not bactericidal it surely is disinfectant.

Most of our knowledge relating to the means of artificial defense is based upon experiments *in vitrio,* which do not represent accurately the conditions as related to practical prophylaxis. Thus, the amount of heat or the strength of chemical required to prevent the future growth of bacteria may be far in excess of the amount necessary to destroy their pathogenic action, and the fact that a certain temperature or a certain chemical does not prevent the growth of bacteria upon culture media in the laboratory is not absolute proof that it does not prevent them from inducing disease. Fortunately, the laboratory bacterial standards usually express conditions in excess of the requirements of the sanitarian, so that, as a rule, they may be safely adopted.

In general, the artificial prevention [illegible] is but the adoption of *sa*[illegible] produce such a st[illegible] *measures*—such as [illegible] electricity and m[illegible] *chemical agents* may be employed; each having its especial field of usefulness. The efficiency of disinfectants in general, and of individual agents, varies with the special parasite, the character of the associated material, the degree in which heat and moisture are present, and the thoroughness and direction of the application. When it is known precisely what organisms are present and what are the actual associated conditions, methods of disinfection may be much simplified. As a rule, nonsporogenous organisms are much more readily killed than those that contain spores; while the presence of heat and moisture, as well as the absence of albuminous material, facilitates the action of disinfectants. The efficacy of disinfectants may or may not be enhanced by their association.

Of the *chemical agents,* watery solutions are, as a rule, most efficient, alcoholic and oily substances least capable of disinfectant action. The addition of *mineral acids* increases the activity in number of chemicals, while *soap solutions* increase the efficiency of some agents and decrease that of others. The penetrative or *solvent action* of the disinfectant may have an important influence upon the results obtained. Thus, upon greasy skins watery solutions may entirely fail, although effective if first the fat be removed. Mercuric chlorid (corrosive sublimate) which under favorable experimental conditions is an energetic germicide, coagulates albumin and hence is not to be depended upon as a disinfectant of [illegible]h substances as sputum. Again, [illegible] protected if growing in a medium that [illegible]es the bactericide used, and [illegible] [illegible]lorid, being transformed [illegible] [illegible]tact with [illegible] [illegible] of fecal material. It is obvious that absolute reliance cannot be placed upon results of laboratory investigation unless in these experiments care has been taken to reproduce substantially the conditions of practice. Moreover, no single, practical disinfectant of universal application is known. In all cases the importance of attacking the infectious agents as close as possible to their source of origin is obvious. For example, it is much simpler and more rational to disinfect a typhoid stool than to attempt the destruction of the myriads of flies or the purification of an extensive water supply that may be contaminated thereby.

To the chemical and physical measures should be added the imperfectly understood *biologic* disinfectants that destroy bacteria or other organized agents even when they are circulating in the living body. The bacteriolysins, elsewhere mentioned, are examples of these important substances. Such products seem to be the only disinfectants that are efficient within the living body. It is hoped that in the development of these substances the key to the arrest of most infectious processes may be found.

MECHANICAL DISINFECTION.

This should always be used for surfaces, such as the skin, that are unable to endure the application of the absolute methods of sterilization; but as it is not a positive means of producing asepsis, it is usually desirable to supplement it by the application of other disinfecting measures. By removal of the fat, dirt and the like, the mechanical cleansing facilitates the penetration of chemical substances later used.

Smooth, oily, polished surfaces may be wiped or washed free from microorganisms by sterilized cloths; but there is always the danger that the process may not be sufficiently thorough to remove all infectious particles. It has been found that a careful wiping of polished metal surfaces, such as the blades of ophthalmic instruments, with a mixture of ether and alcohol is usually sufficient to render them aseptic, provided they are free from depressions such as are caused by the stamp of the maker's name. A few persons with very smooth skins free from gross contamination are able to render their hands practically sterile by so simple a means as thorough washing with soap and sterile hot water, and it has been shown that the number of bacteria upon the hands of any person bears an inverse ratio to the thoroughness and duration of a scrubbing with soap, sterile water and a hand-brush. This is not, however, a purely mechanical sterilization, for soap possesses also a distinct bactericidal action. Stuttgart sand or other abrasive substance is at times mixed with the soap used, to facilitate the removal of the contaminated outer layers of the skin.

Liquids are mechanically purified in part by sedimentation, the bacteria falling to the bottom. They also may be purified by filtration through soil, diatomacious earth, or unglazed porcelain, but no filter seems absolutely bacteria-proof during prolonged use. Experiments indicate that those of unglazed porcelain of the best type are impervious to *Bacillus typhosus,* while those composed of diatomacious earth are gradually penetrated. In filtration through soil, the action of other microorganisms and their products is brought into play. The combined mechanical, chemical and vital processes thus acting, may efficiently disinfect the percolating liquid.

HEAT.

In the application of heat to produce sterilization, dry hot air (*baking*), hot water (*boiling*) or steam (*steaming*) may be employed. At equal temperatures, moist streaming steam is most efficacious, and hot air least so. Each method, however, has special advantages under different circumstances. Some articles are most conveniently disinfected by baking, others cannot be baked but may be boiled, while steam is applicable to still others that cannot satisfactorily be baked or boiled. Microorganisms show great variation in their resistance to heat and, in general, are less susceptible to dry than to moist heat.

Hot Air.

Air must be heated to a temperature about one-third greater than that of steam to have an equal disinfectant action. It is only adapted to dry articles, that will withstand high temperatures, such as forms of steel, glass and earthenware. The temper of surgical instruments is affected, and as hot air has little penetrative action, it should not be used to disinfect closely packed articles, such as bundles of fabrics. The lack of penetrative power is well illustrated in the following table:

WHITELEGGE'S EXPERIMENT WITH RANSOM'S HOT AIR APPARATUS, SHOWING THE PENETRATION OF HOT AIR THROUGH DIFFERENT LAYERS OF BLANKETS.

The air escaping from the apparatus had a temperature varying from 245°F. to 260°F.--(After Notter.)

Duration of Exposure	2 Layers	4 Layers	6 Layers	12 Layers	18 Layers
4 Hours......	220°F.	206°F.	190°F.	162°F.	139°F.
6 Hours......	226	214	208	174	153
8 Hours......	230	221	215	196	182

Dry heat causes evaporation of most liquids, and its sterilizing action may be due to the complete drying of the bodies of microorganisms. It has been employed to sterilize for surgical purposes, catgut and other substances liable to be damaged by boiling in water or by steaming.

Hot Water.

Boiling is a very practical means of sterilizing substances not injured by contact with hot water. It enables one to conveniently apply an even, moderately high temperature for any desired length of time. The exact temperature at which the boiling-point is reached varies with the atmospheric pressure and with the purity of the water. At the sea level, pure water boils at the temperature of 100° C. (212° F.), and the boiling point progressively increases or decreases with changes in pressure. At a very high altitude, boiling temperature may fall to 60° C. (140° F.) or lower. By inclosing the water so that it is always under the pressure of the liberated steam, the boiling-point may be raised, as shown in the following table:

Steam Pressure (Pounds)	Temperature	
	(F.)	(C.)
0	212°	100.0°
5	228°	109.0°
10	240°	115.5°
15	251°	121.5°
20	260°	126.5°
40	287°	141.5°

Boiling water (100° C.—212° F.) is an efficient disinfectant, practically sterilizing within ten minutes all substances to which it has free access. It is true that certain spores will withstand such an exposure, but, so far as known, they do not include any disease-producing species. Even spores of anthrax are killed by boiling water (100° C.) in four minutes and they probably lose their virulence at a much lower temperature. The addition of sodium bicarbonate, borax, or lime, in the proportion of one or two per cent. may increase the penetrative action and prevents the oxidation of iron or steel instruments. Boiling in such a solution, is the method of disinfecting surgical instruments usually preferred. Aluminum, however, is eroded by the presence of alkalies. Syringes, gloves and other articles made of rubber of good quality may be repeatedly boiled in water for brief periods of time without serious injury. By the addition of ammonium sulphate or sodium chloride to saturation, the boiling point may be raised from 100° C. (212° F.) to about 127° C. (260.6° F.), and the presence of these salts enables one to boil without injury gum-elastic catheters, bougies and similar articles damaged by boiling in plain water.

Alcohol boils at a much lower temperature than water and has been used in surgical practice especially to sterilize catgut. As it is usually employed it seems to be an unreliable agent for this purpose. Far more efficient is the boiling of catgut in cumol at a temperature between 133° and 160° C.

Steam.

This is one of the most efficient and generally useful of all artificial germicides. Sterilization entails the consumption of energy, and as steam contains relatively a much higher potential of energy in the form of latent heat than does boiling water or heated air, it is a much more active sterilizing agent. To convert a given weight of water at the boiling-point into steam requires nearly one thousand times as much heat as is required to raise the temperature of water from 211° F. to 212° F. This great amount of latent heat is stored up in steam and liberated upon its condensation. From this it follows that to obtain the most efficient action of steam necessitates at least a partial condensation. Thus, if superheated steam be passed through bundles of fabrics, it will be found that the greatest action occurs in the interior of the bundles, where a partial condensation can take place, rather than upon the exterior, where fabrics are quickly raised to such a high temperature that almost no condensation occurs. For the same reason superheated steam which acts at a temperature far above its point of condensation, is relatively much less efficient than streaming saturated steam.

Saturated steam has a temperature corresponding to the pressure under which it is held, so that the slightest cooling will result in condensation. At the pressure of one atmosphere, for example, saturated steam has a temperature of 100° C. (212° F.), and the point of saturation varies with the pressure according to the table previously given. *Superheated steam* has a temperature exceeding that corresponding to the pressure at which it exists. It does not condense until it has cooled to the saturation point. It is obtained by heating saturated steam or by adding certain salts such as sodium chlorid, to the water in order to raise the temperature at which steam will be liberated. Saturated steam has relatively greater penetrative power and disinfectant action than has superheated steam. In condensing it imparts to the surrounding media a temperature above that at which it exists; for as it comes in contact or enters articles to be disinfected, the cooling produces a partial condensation, and the liberated *latent* heat is transferred to the material. The successive great reductions in volume resulting from the condensation attract more and more steam to the area, so that penetration through even large bundles of fabrics quickly takes place.

For the use of steam at high temperatures, forms of sterilizers capable of withstanding high pressure, known as *autoclaves* or *steam pressure sterilizers,* are employed. Any air remaining in such an apparatus greatly interferes with the action of the steam. To insure sterilization, therefore, it is essential that all air be first expelled, either by permitting the steam to escape for a considerable time before sealing the apparatus, or else by exhausting the chamber two or three times during the process of sterilization. If great care be not taken in this regard and to ensure sufficient circulation of the confined steam, the pressure sterilizer is apt to be untrustworthy. The method of intermitting the action of steam with the formation of partial vacuum is readily carried out by a simple condensing device, and greatly enhances the efficacy of the method.

Superheated steam does not moisten paper or fabrics, and for this reason may be used to sterilize letters and the like. At the ordinary atmospheric pressure, streaming saturated steam rapidly destroys all pathogenic organisms and their spores, and, for general purposes, has been found the most convenient and efficient practical measure. For heavy work with limited space and with expert supervision the vacuum method with superheated steam is advantageous. Steaming steam tends to wet articles that are closely packed, while employment of the vacuum and of superheated steam prevents wetting.

COLD.

It has repeatedly been observed that cold does not destroy pathogenic bacteria, yet the number of microorganisms progressively diminish in frozen articles, indicating that cold is a slowly acting germicide as well as a disinfectant. Prudden found that bacilli of typhoid fever would withstand freezing for one hundred and three days, although the action of alternate freezing and thawing was found to be injurious to their growth.

Ravenel and McFadyen exposed various bacteria to the low temperature of liquid air (—190° C., —310° F.) for periods varying from a few hours to seven days, without destroying their viability. Portions of infected tissue from tuberculous lungs have been kept frozen for four months without destroying their property of infecting guinea-pigs. A few organisms are able to multiply at or below freezing temperature; thus, meats kept in cold storage may become moldy.

LIGHT.

The *ultra-violet rays* (actinic rays) from the sun or from electric light have a pronounced germicidal action, well marked in the case of the direct solar rays, requiring a much longer time for disinfectant action when diffuse; while the rays from the electric light are much less efficient. The direct sun rays are much more powerful than those from a 100 candle-power electric arc light at a distance of one meter. As the arc light is richer in actinic rays than is the incandescent light it is the more active. Clearness of the atmosphere, freedom from dust and fog, and the absence of any interposed transparent medium, as glass, which interferes with the transmission of ultra-violet rays, increases the action of light. The red and infra-violet rays possess little bactericidal value. The disinfectant action of light has been clearly demonstrated after the rays have penetrated clear water to the depth of at least 30 centimeters; so that it is evident that exposed water, perfectly clear and not of great depth, may be freed from pathogenic organisms by sunlight alone. The germicidal action seems to be due partially to changes in the medium involving its contained oxygen, but chiefly to a direct action of the actinia. Bacterial toxins are also rendered inert by light. It is evident, therefore, that sunlight will act chiefly as a surface disinfectant of translucent or opaque bodies. Tubercle bacilli are quickly killed by exposure to the direct solar rays, the time varying, according to circumstances, from a few minutes to several hours; while the diffuse rays will destroy these organisms in from five to seven days, their virulence diminishing before their death (Koch). Practically all pathogenic bacteria and spores may be destroyed by a sufficiently prolonged exposure to the actinic solar rays.

ELECTRICITY.

It is extremely difficult to estimate the bactericidal action of electric currents, as it is practically impossible to apply them without inducing chemical changes in the surrounding media. These chemical substances frequently have a marked disinfectant action, but that of electric currents in themselves requires greater proof. Induced currents of from 10 to 20 amperes, acting upon bacteria inclosed in tubes of a diameter of 3.5 centimeters, were found by Spilke and Gallstein to kill microorganisms in one or more hours, and to restrain their growth if applied for shorter periods. It is probable that of itself electricity is at most a feeble bactericide.

DESICCATION.

Absolute dryness is probably destructive to all microorganisms and their spores, and the efficiency of dry heat as a disinfectant seems to depend in a large measure upon this action. The organisms of the colon group, such as *Spirillum choleræ, Bacillus typhosis* and *Bacillus coli* are more readily destroyed than those of tuberculosis and diphtheria or especially those forming spores. Koch found that the cholera spirillum was killed by drying three hours, if in thin layers ; Rosenau, that the plague bacillus soon died in dry air at the temperature of the body, and Pfuhl that the bacillus of typhoid fever died after eight or ten weeks of drying. The bacteriologist finds it necessary to frequently transplant bacterial cultures to keep them from drying. The tubercle bacillus and spore forming organisms may withstand ordinary drying for months. Much depends upon the character and amount of the associated protecting material.

CHEMICAL AGENTS.

Gases.

Formaldehyde.—Formicaldehyde, methylaldehyde or oxymethylene is a pungent irritating gas formed by oxidizing the vapors of methyl alcohol by passing them over incandescent platinum sponge or coke, the formula being $CH_3OH + O = CH_2O + H_2O$. Forty volumes per cent. is soluble in water, such a solution being sold under the trade names "formalin," "formal," "formol," and the like. If attempts be made to produce condensation or concentration it is prone to polymerize into *paraformaldehyde* (trioxymethylene or paraform, $C_3H_6O_3$) a white, solid substance, which when gently heated is reconverted into formaldehyde. The gas combines with albuminous substances, rendering them stable and incapable of gastric digestion, and this tendency to combine with organic compounds makes it a good deodorant. Ammonia neutralizes it and converts it into an inert compound.

Application.—Formaldehyde is the most efficient of the gaseous disinfectants at present known. It has, however, little penetrative power, and its action is, therefore, chiefly that of a surface disinfectant. It may be applied (1) as a *watery solution,* being active in 0.4 to 4 per cent. in water (1 to 10 per cent. of the commercial solution); (2) as a *spray* produced by projecting air or steam through a concentrated watery solution; (3) as a *gas* generated by (a) passing the vapor of the methyl alcohol over a heated platinum sponge in a special apparatus, (b) heating pastilles of paraform in a special lamp, (c) evaporating the gas from a watery solution by means of a special device or (d) the slow evaporation from sheets saturated with formaldehyde solution and hanging in the room. For room disinfection the evaporation of the gas and the method of spraying the formaldehyde by a jet of steam have proved the most valuable. The direct generation of the gas from wood-alcohol is usually subject to the disadvantage that much of the alcohol may be lost through conversion into carbonic oxid or carbon dioxid, and it is difficult to gage the quantity of formaldehyde generated. Paraform pastilles are efficient provided a sufficient number be used and the aqueous vapors produced by burning alcohol in the lamp be permitted to mix with the gas. In using the spray a protecting device for the eyes is necessary. For efficient action it is important that the room be tightly sealed, that the entire quantity of disinfectant enter the room within a short space of time, that the surfaces of all articles to be disinfected be freely exposed to contact with the gas and when possible, slightly moistened; and that the room be kept tightly closed for twenty-four hours. Sheets of paper and envelopes are readily penetrated, and leather or delicate fabrics are not injured. Although smaller amounts are often advised, one pint of the saturated aqueous solution of formaldehyde or, according to the experiments of Notter and others, not less than fifty, one gram paraform pastilles should be used for each 1,000 cubic feet of air space. As imperfect gaseous diffusion often interferes with a disinfectant action, when large rooms are to be disinfected, the gas should be discharged at several different points. Under the best conditions, absolute disinfection is not usually obtained. Flugge considers the result to be good if 90 per cent. of the pathogenic organisms are destroyed. The pungent odor of formaldehyde gas may be removed by the evaporation of ammonia water. Formaldehyde is an efficient agent for disinfection of script or coin. Sputum, vomit, feces, urine, and the like may be efficiently disinfected by intimate mixture with sufficient of the solution to give a proportion of one per cent. of the gas. For the purposes of general surgical disinfection it is unsuited. It makes the skin rough and leathery, and has a destructive action on the delicate tissues. Distressing skin affections of the hands of surgeons have followed its prolonged application.

Formaldehyde is often an unreliable agent for the destruction of vermin. Mosquitoes, flies and other arachnids usually are killed, but bedbugs, roaches and possibly fleas secrete themselves in the cracks and crevices less accessible to the gas, and thus often escape. The larger animals are destroyed if left for a number of hours in an apartment in which the gas is present in large amount. For the destruction of vermin, sulphur dioxid is more valuable.

Sulphur dioxid, SO_2.

This gas is usually generated by burning brimstone or prepared sulphur candles in the dwellings, hospitals barracks, etc., that it is desired to disinfect. It may be generated by burning carbon bisulphide in a suitable lamp and may be used with greatest precision if taken from tanks of the liquid gas. Repeated experiments show that as it is commonly employed, it is unreliable as a germicide. The Committee on Disinfectants of the Public Health Association, advised that at least 4 volumes per cent. of the gas be present in the air of the room to be disinfected for at least twelve hours. When burned in the usual way, it is difficult to comply with these conditions. The gas diffuses rapidly, tarnishes metals and in the presence of moisture has a bleaching action on many colors. At least 4 grams (60 grains) should be burned for each cubic meter of air space, and there should be a simultaneous liberation of aqueous vapor, for the gas is comparatively inefficacious in dry air. In burning brimstone it should be broken in small pieces well wetted with alcohol and not more than one pound should be burned at one place. Thus, for large rooms, sulphur should simultaneously be burned at a number of places. To guard against fire, the metal vessel holding the sulphur should be supported in a large pan containing water. It is only under favorable conditions that more than 20 per cent. of the sulphur used is consumed. It is a very valuable agent against vermin, destroying flies, fleas, mosquitoes, roaches, bedbugs, and other insects, and may also kill rats and other larger animals. For those diseases, therefore, that are transmitted by vermin it may be of greater value than substances having a higher germicidal power but less destructive to animal life.

Oxygen and Ozone.

The ordinary form of oxygen is inefficacious as a germicide, but in the form of ozone, especially in the nascent state, has a decided oxidizing action. In sufficient amounts to be actively germicidal it is irritating to the mucous membranes and for practical purposes it is also rendered inapplicable from the expense and practical difficulties underlying its production.

Bromin, chlorin and *iodin,* in the gaseous state, are all efficient germicides, but are unsuited for general use by reason of their irritating and toxic qualities, and their chemical affinities, which result in the bleaching and deterioration of colored fabrics, and the tarnishing of metallic surfaces.

LIQUID DISINFECTANTS.

The disinfectant powers of inorganic agents have in part been found to bear a relationship to the character of their ionization. This refers to the disassociation of acids, bases and solids into electropositive or electronegative ions when they are in watery solution. Paul and Kronig have found that most acids act as disinfectants in accordance with their electrolytic disassociation; bases in accordance with the concentration of the hydroxyl-ions; while oxidizing agents have a disinfecting action related to their electric activity. The halogens, chlorin, bromin and iodin have a disinfectant power in inverse ratio to their atomic weight. The theory of ions would seem to explain the inefficiency of many disinfectants when in alcoholic solution or in contact with albuminous material. Other substances, as carbolic acid, are said to have a direct molecular action upon bacteria, ionization not taking place. The bactericidal action of certain agents seems to be unrelated to the state of ionization.

Carbolic Acid (*Phenol*).

When pure, phenol occurs in the form of colorless needle-like crystals, soluble in about eleven parts of water, but for convenience it is usually liquefied by the addition of a small percentage of glycerin.

Crude carbolic acid is a dark-colored liquid having a powerful odor and containing cresols and other coal-tar derivatives. Phenol precipitates albumins without entirely losing its disinfective action. It is usually employed in the strength of from 1 to 5 per cent. Its germicidal power is moderate, and at present it has a rather limited use in surgical practice. The *Bacillus typhosis* is quite tolerant of this agent and may become accustomed to solutions of the usual strength. It decreases tactile sensibility, renders the skin rough, and if applied to portions of the body for long periods of time, even in weak solution, may produce local necrosis and gangrene.

The pure acid is caustic and is used as an antiseptic cauterizant in appendectomy, for swabbing out tuberculous abscesses and the like. It has also been employed for hand disinfection, the liquefied acid being immediately neutralized by applying strong alcohol.

Cresol.—The various cresols, *meta-*, *tri-*, *ortho-*, and *para-cresol,* are all disinfectants. Excepting *tricresol,* which has been extensively used as a preservative of antitoxin serums, the cresols are usually employed in combination rather than singly. All combine well with oils, and with soaps, and have the advantage of not corroding metallic surfaces.

Creolin.—Creolin contains about 4 per cent. of cresol, together with soap and phenol. It is a black, tarry liquid with a penetrating odor. It makes, if mixed with water, an opaque milky solution. It has been credited with marked disinfectant power, but this is evidently an error, as anthrax organisms will grow after they have been immersed in pure creolin. Hirst has reported the development of tetanus from intrauterine irrigations of creolin solutions made with rather muddy tap-water. It may be employed with advantage against lice, fleas and other animal parasites.

Lysol.—Lysol contains about 50 per cent. of cresol, mixed with the neutral potash soap, and when mixed with water, forms a transparent, soapy solution. It seems to be more valuable as a germicide than carbolic acid, and is extensively used in surgical practice.

Other cresol compounds for which high antiseptic powers have been claimed are *saprol,* consisting of 20 per cent. mineral oil with 80 per cent.

of crude carbolic acid; *solveol,* a concentrated aqueous solution containing over 25 per cent. of cresols; and salutol, containing 60 per cent. of cresols in sodium cresol.

Saprol has been advised for the disinfection of excreta and privy vaults. Solveol and salutol are said to be less irritating and more potent than carbolic acid as general surgical disinfectants.

Alcohol

Alcohol is a good antiseptic, but is a weak germicide. In laboratory experiments it has been found most efficient in 50 per cent. solutions, the germicidal value diminishing progressively with the addition or subtraction of water. When heated, the weaker alcohols are found to be more potent, while many bacteria may be boiled in concentrated alcohol without destruction. Too great reliance, therefore, should not be placed in the sterility of catgut boiled in alcohol or instruments dipped in alcohol and momentarily flamed. Strong alcohol reduces the effectiveness of mercuric chloride, while sublimate, carbolic acid, lysol, or thymol are said to be more powerful as germicides when dissolved in 50 per cent. alcohol than in water. When applied to moist surfaces of the body, alcohol is of course, diluted, and so proportionately stronger solutions should be used than those found efficient in the laboratory.

Cumol is a yellowish, oily liquid, boiling at about 160° C. (331° F.). Catgut, thoroughly dehydrated by dry hot air, may be boiled without injury in cumol, and afterward the cumol may be driven off by dry heat. This is one of the best methods of disinfecting catgut.

SOLID DISINFECTANTS.

Soaps.

Not only are soaps of good quality sterile but they have a well-marked bactericidal action. The experiments of many observers, including those of the writer, indicate that many pathogenic bacteria are killed within a short time (5 to 30 minutes) by solutions containing 3 to 10 per cent. of hard soap of good quality. This action does not depend upon the free alkali present, as it occurs in soaps practically neutral. The pathogenic cocci seem more resistant than the organisms of cholera and typhoid fever. Although the soft or potash soaps seem more active, as a rule, they are less desirable than sodium soaps on account of their greater impurity. Hard soaps containing rosin are considered less potent than the purer forms, and in any case, dilution or admixture with hard water reduces the bactericidal action. With an appreciation of the inherent germicidal power of soaps the fatuity of adding traces of carbolic acid, boric acid, creolin or similar agents to render them antiseptic is apparent. It has been found possible, however, to enhance the bactericidal action by introducing ½ to 3 per cent. of mercuric biniodide or the double iodide of mercury and potassium. A 1-per-cent. solution of such a soap was found to destroy ordinary pathogenic bacteria in one minute. For hand disinfection, Mikulicz strongly commends the German spiritus saponatus, to be applied in full strength for five minutes.

Mercuric Chlorid (Corrosive Sublimate).

Mercuric chlorid is one of the few antiseptics generally employed in surgical practice. It is easily decomposed and rendered inert by contact with metals or organic matter, and a film of oil or a coating of albuminous matter may prevent its action. Its use is restricted chiefly to surgical practice, where it is employed to cleanse the hands, the operative field, and to serve as an irrigating solution for wounds. The first claims made by Koch, and others, about its extraordinary germicidal properties have been modified by later investigations, which show that organisms that apparently have been killed by this salt often regain their vegetative properties when the sublimate is neutralized by the addition of ammonium sulphid. As this neutralization has often been omitted experimentally, many of the tables of germicidal values are useless. To render it more stable and effective, it is usually combined with citric or tartaric acid, or sodium or ammonium chlorid. Objections to its use are its toxicity, unstability, lack of penetrative power and destructive action upon metals. It is used in the strength of from 1:500 to 1:10,000. The former strength is very apt to produce a marked local irritation, the latter is so weak as to be untrustworthy. It should not be used to disinfect solutions containing organic matter such as sputum, urine or typhoid stools. To insure its more thorough action, dirt, fat and loose epithelial scales should be removed from the skin before the sublimate solution is applied. To this end the body surface is first thoroughly scrubbed with soap and hot water and a solvent such as turpentine, ether or alcohol then applied.

Mercuric iodid is insoluble in plain water, but soluble when an excess of potassium iodid is added. It is said to have nearly the disinfective powers of the bichlorid without its irritating action, its destructive effect upon metal instruments, or its unstability.

Silver Nitrate.

Although this salt blackens organic matter on exposure to light, is easily decomposed and is irritating, it seems to be one of the most efficient disinfectants for mucous surfaces. Thus, opthalmia neonatorum may be prevented by Crede's method of introducing one or two drops of a two-per-cent. solution of silver nitrate into each eye of the new-born infant. There is evidence that this agent, if used with sufficient promptness may also abort gonorrheal infection of the urethra or other mucous membrane. Similar infections of the mouth or pharynx seem at times to be arrested by the use of this agent. Although less irritating, more stable, and shown *in vitrio* to possess bactericidal power, it is questionable whether the newer organic compounds of silver are clinically as efficient germicides as is silver nitrate, which has the advantage of destroying the exposed layer of contaminated cells.

Chlorinated Lime (Chlorid of Lime).

This consists of a mixture of calcium chlorid and hypochlorite, and owes its efficiency chiefly to the latter. It should contain at least 35 per cent. available chlorin (U. S. P.) and should be dry, friable, and nearly free from the odor of chlorin until moistened. It is an efficient disinfectant in a strength of 1:400, and solutions of 1:1,000 were found by Bolton to destroy the organisms of cholera and typhoid fever within two hours.

For *excreta* it is one of the most efficient practical disinfectants. The committee on disinfectants of the American Public Health Association advise that six ounces of chlorinated lime, containing at least 25 per cent. of available chlorin, should be dissolved in one gallon of water. For use, one quart of this solution should be mixed intimately with the typhoid dejections, and permitted to stand at least one hour before being thrown into the privy or drain. As a hand disinfectant the value of this agent was, years ago, conclusively shown by Semmelweiss in the prevention of puerperal infection. Recently its use has been revived in a modified way. About 8 grams (2 drams) of chlorinated lime are placed on the palm of the hand, a crystal of sodium carbonate weighing about 0.5 gram (8 grains) added, the mixture moistened with water, and thoroughly rubbed into the hands and forearms. Especial care is to be taken to carry it under the nails and along the ungual folds, with swabs of cotton. Finally, it is washed off with sterile water. Its use should always be preceded by the customary cleansing with brush, soap and hot water, and may be followed by the use of other germicides. It has the disadvantage of rendering the skin rough, and the nails brittle. In the dry form it is a valuable agent when dusted in privy vaults, acts as a deodorant disinfectant, and also repels insects, mixed with manure it serves a useful purpose in preventing the propagation of flies and other insects.

Sodium hypochlorid solution (Labarraque's or Javelle's solution) consists of chlorinated lime 75, sodium carbonate 150, water to 1,000. It should contain at least 2.6 per cent. by weight of available chlorin. It is a useful antiseptic, but is less commonly employed than the simple chlorin solutions that seem to be equally efficient.

Metals.

The development of microorganisms may be restrained by contact of the solution containing them with certain metals, such as silver or gold;

probably because traces of metallic salts are formed. Surgeons have availed themselves of this action, silver wire suture being used in operating upon portions of the body liable to infection, and silver foil to cover wounds. Of the great number of other chemicals that have from time to time been in repute as disinfectants mention may be made of *ferrous* and *ferric sulphate, ferric chlorid, zinc chlorid, aluminum chlorid, copper sulphate.* These are feeble disinfectants, rarely to be employed when the more efficient agents can be secured. In this connection note may be made of Miller's observation that copper amalgums when placed in the cavities of carious teeth have a remarkable influence in arresting decay.

Boric acid in 10-per-cent. or saturated (about 17-per-cent.) solution forms a mild lotion for delicate surfaces detergent and antiseptic, although scarcely to be considered germicidal.

Iodoform.—The value of iodoform as a dressing for infected wounds is attested by a multitude of able clinicians, yet in the laboratory it seems to have little bactericidal power. It often contains living bacteria and infection has resulted from the injection of mixtures of iodoform and bacteria. These experiments are not absolute proof that in wounds iodoform does not gradually liberate antiseptic compounds or stimulate the cells to greater resistance, yet they indicate that it should be sterilized before use. This may be accomplished by exposing it to formaldehyde, solutions of mercuric chloride or by tightly sealing it in a bottle containing a little moisture which is placed in a steam sterilizer or boiling water for one hour. The toxic action of iodoform as well as that of phenol, mercury and silver salts should be remembered. In large wounds it should be avoided or used sparingly, and in general small amounts only should be employed.

CHAPTER XIV.

THE INHIBITION OF THE FACTORS IN DISEASE.

ANIMAL CONVEYORS.

THE LIFE-HISTORY OF THE MOSQUITO.

Development.

Ova.—The female insect usually lays her eggs upon the surface of water, although it is possible that at times the eggs are deposited upon grass or other substances from which they may be later washed by rains into pools. In from twelve hours to three or five days after the eggs are laid the *larvæ* or wigglers emerge. The wigglers breathe air through a projecting segment given off near the anal extremity and containing a double trachea. This must frequently be brought into contact with the atmosphere or the larva will drown. The wigglers feed on free particles in the water, especially upon algæ. After a variable number of days they enter the *pupa stage,* which is characterized by a marked enlargement of the thoracic segment, from which project two ear-shaped respiratory siphons that assume the functions of the former respiratory tubes. A number of days later the imago emerge from the pupa. The entire cycle of development usually occurs in from ten days to four weeks; but if the weather be cold, the larval or pupal stage mav be prolonged indefinitely. The larvæ may remain frozen for a long time in ice without being destroyed. They are killed rapidly by drying.

Adult.	Culex.	Anopheles.
Palpi.	Female has diminutive palpi with 3 segments. The male has palpi nearly as long as proboscis, with 5 segments.	In both male and female nearly the length of proboscis and with 5 segments.
Wings.	Usually not marked.	Usually spotted.
Body axis.	Forms a nearly straight line. Parallel with the surface on which the Culex alights.	Is curved making the Anopheles "hump backed." Forms an angle often approaching 90° with the surface on which the insect rests.
Note.	Shrill, high pitched.	Several tones lower and less clear than that of Culex.
Biting.	Usually pauses before biting.	Bites immediately on alighting.
Time of appearance.	Evening and also during day.	After 6 P. M.
Breeding places.	Usually artificial collections of water, tin cans, drains, sewers, etc.	Usually natural collections of water, streams, pools, etc.
Eggs.	200 to 400 arranged vertically with their sides coherent, forming a boat-shaped mass, that is concave below, convex above.	Float loosely connected or isolated in water on their sides, are not united and the egg mass form no characteristic figure.
Larvæ.	Form an angle of about 45° with the surface of the water. Frequently descend and seem heavier than water.	Unless disturbed habitually remain at the surface, with which their bodies lie parallel. Seem lighter than water so that they descend with effort. The respiratory siphon is longer, the head parts smaller, than corresponding parts of Culex.
Pupa.	Float nearly vertical to the plane of the surface of the water. Respiratory siphons longer and narrower than those of Anopheles.	Body oblique to the surface, respiratory siphons shorter and broader.
Duration of development.	Ten days.	Twenty-four days.

Howard found that they died in from twenty-four to forty-eight hours after the water had been drained from mud containing them.

Adult mosquitoes may hibernate during the winter. They are often carried to new neighborhoods by trains, stages or other conveyances. While Howard believes that they rarely fly long distances, they have been noticed far out at sea. They have been kept alive under artificial conditions for over two months, but usually they die within a few weeks.

As only anopheles transmit malaria, it is important to note their distinguishing features from those of the Culex.

The *yellow fever mosquito* (*Stegomyia fasciata*) has been found in tropic and subtropic, but, thus far, not in the temperate or arctic regions. It is characterized by conspicuous silver stripes upon the thorax and abdomen, and bands upon the legs. The larva and pupa resemble those of the genus Culex. The larva have been found in cisterns and in small artificial collections of water in and about houses. As it is active in the early afternoon as well as at night, it has been called the "*day mosquito.*"

The Destruction of Mosquitoes.

In a single summer one female may give rise to twelve generations, and as the females of the genus Culex deposit from 40 to 100 eggs, and of the Anopheles from 200 to 400 eggs at one time, the possibilities of mosquito multiplication in a single season almost exceed comprehension. Happily many natural agents cause a high mortality in the mosquito family, so that practically this number is far from being approximated.

The Destruction of the Larvæ.—The most effective measures are those directed against the *breeding* of mosquitoes. For successful breeding a suitable collection of water is the first essential, for it has not been shown that the larvæ develop apart from the water. By filling in hollows, by draining swamps, and by preventing the accumulation of water in discarded cans, pails, bottles, and similar receptacles much may be accomplished. Collections of water that do not remain over nine days may be ignored, as the period from the deposition of the eggs to the emergence of the adult insects probably is rarely less than ten days. Collections of water that are permanent or indispensable should be made inaccessible to the insects or uninhabitable by them. Lakes, pools, springs, watering-troughs and the like may be stocked with the natural enemies of the mosquito. The fish that have been especially commended for this purpose are *top minnows.* (*Gambusia affinis*), *sticklebacks* (*Gasterostous aculcatus*) and the common sunfish (*Lepomis gibbosus*). *Salamanders* are also useful. The larvæ of the *dragon-fly* and certain *water-beetles* prey upon the larvæ of mosquitoes, but practical means of introducing these into the breeding places have yet to be suggested. As the Anopheles seek the protection of water plants, these measures may not be entirely efficient. The larvæ of Culex have been observed to destroy those of the Anopheles. Tanks, cisterns and rain-water barrels should be efficiently screened to prevent access of the gravid female to the water or, better, the water surface covered by a film of coal oil. This kills the adult females as they attempt to deposit their eggs, prevents oviposition and destroys the larvæ. The crude, fuel oil, is by Howard commended as preferable to the more volatile grades. In Cuba the army orders of December, 1901, advise, "an application of one ounce of kerosene to each 15 square feet of water, twice a month." Water in cisterns, tanks and rain-barrels may be treated similarly, and remain useful for washing or drinking purposes, provided it is drawn off from below, so as not to disturb the surface film. On large bodies of water the oil may be sprinkled, sprayed, spread with swabs, or delivered below the surface by means of perforated pipes. It is important that the entire surface be covered; otherwise the larvæ may collect in the places free from oil. This treatment does not injure the fish. The use of potassium permanganate has been urged, but the quantities required, and its rapid disintegration, render the method impracticable.

Destruction of the Imago.—Adult mosquitoes are caught and destroyed by dragon-flies, bats, and many species of night birds. Houses are best protected from them by accurately fitted window and door *screens.* A simple and effective means for getting rid of those that have gained entrance is afforded by a tin cup fastened to the end of a stick and containing a small quantity of *kerosene.* When this is placed under the resting mosquito, it promptly falls into the oil and is killed. The insects may be stupified by blowing *pyrethrum* (Persian powder) about the room or burning small cones formed of the dampened powder. The stupified insects may be swept up and burned. Fumigation with *sulphur* is generally efficacious, and should be applied to holds of vessels, passenger coaches, and other conveyances that come from a malarial or yellow fever centre. *Chlorin* gas generated by pouring sulphuric acid upon chlorinated lime has also been advised for this purpose. *Hydrocyanic acid gas* is efficient but dangerous.

Eucalyptus trees and castor-oil plants have been thought to emit vaporous substances distasteful to culicidiæ. Eucalyptus trees planted about marshy ground may aid by drying the soil, and their foliage may serve as a screen, interrupting the mosquitoes' flight. The value of the eucalyptus as well as that of the castor-oil plant is probably overrated. Mosquitoes have even been observed on the latter.

To keep mosquitoes from the body camphor and such essential oils as those of lavender, citronele, pennyroyal, peppermint and eucalyptus are advised. Howard gives the following formula which is highly recommended as an application by E. H. Bane: Castor oil, 1 ounce; alcohol, 1 ounce; oil of lavender, 1 dram. An ointment of petrolatum impregnated with peppermint and eucalyptol is also useful and convenient of application. It is said that the hanging about the beds of cloths saturated with solutions of carbolic acid or of one of the essential oils mentioned will keep mosquitoes away.

It is of the utmost importance that mosquitoes be prevented from contamination by biting patients with yellow fever, malaria, or filariasis. Such persons should be protected by careful screening. By the use of quinin in doses of from 5 to 15 grains or more daily, not only is a prophylactic action against malaria obtained in the individual, but usually the drug also serves to keep the peripheral blood in infected persons free from the parasites, so that there is less danger of their transference to the mosquitoes. Koch considers the general use of quinin a feasible means of exterminating malaria in a country. Unfortunately, certain forms of the parasite, as the estivo-autumnal variety, are not readily influenced by this drug.

The Destruction of Flies.

In all diseases in which infection occurs through the alimentary tract, flies should be considered as important carriers of the infection, until this possibility is absolutely disproved. As has been previously shown, flies are capable of carrying not only bacteria, but also the eggs of various parasitic worms that infest the intestines. It has been proved that they may deposit contaminating microorganisms upon food and in surgical solutions, upon the skin or in wounds. Instead of serving as useful scavengers, their presence seems to be a constant menace, whether in the operating room, ward, camp, barracks or dwelling.

Life-history.

The common fly, *musca domestica,* usually deposits her eggs, about 120 in number, in the crevices of the manure piled so frequently about stables. Under the influence of heat and moisture, the larvæ are hatched and pass, after several stages, lasting in all from five to seven days, into the pupa stage. Five or seven days later the fly matures from the puparium. The entire period of ovulation lasts, therefore, from ten to fourteen days and the reproductive potentialities of a single fly in one season are enormous.

In the larval or pupal stage a fly may be *destroyed* by gnats or other hymenoptera or by certain beetles or scorpions, while many birds also feed upon them. In the adult condition their chief enemies are spiders and birds, although at times they become diseased from a parasitic fungus (*Empusæ muscæ*). To rid a community of flies it is of first importance that their natural breeding places be abolished. All forms of excreta, including various manures, together with the soiled bedding from stall or stable, should be made inaccessible to flies, either by proper inclosure or by stacking it in piles covered with earth or lime. The frequent adding to the manure of layers of chloride of lime is advised by Howard. This destroys the larvæ. The chief source of contamination of flies is the excrement of man or certain lower animals. Their favorite places of rendezvous are the stable, privy, or latrine, and the kitchen or mess-room. As thus far it has been impossible to exterminate these pests, it is imperative that they should at least be *denied access* to sources of infection, and to food. In camps, where transmission of typhoid fever by flies is a special danger, the former object may be attained by the chemical disinfection or incineration of feces, by burying the excrement (most easily done in long shallow furrows) or by keeping it well covered with dry earth, ashes, lime, or chlorinated lime. The protection of food is best obtained by the general adoption of screens in the camp. Instead of individual tents a general mess-hall, carefully protected by fly-nets should be used for dining. The methods of fumigation useful against mosquitoes may likewise be applied for the destruction of flies. It is of special importance that flies be excluded from operating rooms and from wards, especially if the latter contain patients suffering from contagious diseases. Sputum cups, which often attract insects, should contain a disinfectant solution and be provided with lids that should be closed except during use.

The Extermination of Fleas.

The fact that adult fleas live upon the blood of warm-blooded animals, possess powerful organs of locomotion, and frequently change their hosts, enables them to play an important part in the dissemination of disease. The common house flea (*Pulex irritans*) and the cat and dog flea (*Pulex serraticeps*) most often attack man. The eggs of the house flea, 8 or 12 in number, are laid upon the hair of animals, from which they readily fall, or in shaded dusty places. From the eggs larvæ develop; these are transformed into pupa, and may or may not form cocoons, from which the adult insect emerges, the entire period being about four weeks. The reproduction of the dog and cat flea is more rapid. In the larval stage, fleas are readily killed, but the adults are resistant. Carpets, rugs, mattings and collections of dust and rubbish, harbor them. By using bare floors and by frequently sweeping, their development in houses can usually be prevented, provided a new supply is not repeatedly introduced by the domestic animals. Pyrethrum is efficient against the larvæ, and when rubbed into the hair of animals will stupefy the adults so that they may be removed and destroyed. A solution of creolin forms an efficient wash. To kill the pests in carpeted rooms is more difficult. Dusting with pyrethrum, sprinkling with benzine (taking care that there is no means for its ignition), or fumigation with formaldehyde or sulphur dioxid may be tried. It may be necessary to remove the carpets and have the floor scrubbed. The adult fleas may be caught by scuffling along the floor in one's bare feet and seizing them by the wetted fingers as they alight upon the legs, or they may be enticed upon sticky fly paper affixed above the ankles. In the presence of infection that may be conveyed by fleas domestic animals should be excluded from human habitations, and rats and mice, which so frequently harbor the insects, exterminated.

The Destruction of Bedbugs.

Bedbugs secrete themselves in crevices of walls and beds, in which they lay their eggs and from which they emerge at night to suck the blood of animals. It has been asserted that they live in large numbers in woods and are carried by birds and bats. This seems to be insufficiently substantiated. To secure their removal all crevices should be obliterated by repapering walls and by varnishing or painting beds and bed-springs. Sulphur fumigation is often very efficient and the use of pyrethrum powder is a good palliative. Bed-rooms and beds should be frequently renovated and metallic bedsteads are preferable to those of wood. Formaldehyde disinfection often fails to destroy bedbugs, but the washing of infected articles with strong solutions of mercuric chloride is often advantageous.

The Destruction of Lice.

A single species of louse is parasitic only upon single species of animal. Indeed, certain forms limit their activities to a particular part of the body. Thus, head lice remain in the hair of the head, body lice remain in the clothes or upon the hairless parts of the body, while the crab louse infests particularly the coarser hairs of the body, especially of the pubis, and does not live in the hair of the scalp. The nits or eggs are deposited upon hairs, to which they firmly adhere. From the eggs the insects emerge as adults in miniature. The eggs of the body louse are deposited in the folds of clothing. The use of a mercurial or sulphur ointment, or a lotion of staphisagria (stavesacre) or delphinum (larkspur) for the hairy parts of the body, and sulphur fumigation of the clothes will readily destroy these parasites.

The Destruction of Rats.

The destruction of rats is demanded in the presence of plague and perhaps certain other diseases. In maritime cities it is of especial importance that rats be prevented from coming ashore from vessels either by anchoring the vessel far out or by keeping the gang-plank in and the hawsers guarded by properly shaped metal funnels.

In an infested vessel the rats may be poisoned, trapped, or suffocated. *Trapping* is not to be depended upon. *Poisoning* by food is less certain than that by certain gases. Of these *sulphur dioxid*, generated by burning sulphur, is effective if in sufficient concentration. Asphyxiation may be produced by discharging the contents of cylinders of liquefied *carbon dioxid* into the hold until lighted candles lowered into the vessel are promptly extinguished. The use of the more toxic *carbon monoxid*, produced by burning charcoal is advocated by De Farrari. Six kilos (13 pounds) of charcoal are used for each 100 cubic meters (3,530 cubic feet) of space and ignited by the use of kerosene. All openings are kept tightly closed for eight hours and then thoroughly aired before it is entered by men.

Hydrocyanic acid, advised for the destruction of rats as well as insects and other vermin, is one of the most efficient agents for this purpose known, but it is dangerous and expensive. Like other gases, it has little penetrative power, and it may discolor and alter the texture of fabrics. Fulton advises the use of 1 kilo (2.2 pounds) of potassium cyanid for each 283 cubic meters (1,000 cubic feet) of space. To each kilo is added 1½ liters (quarts) of sulphuric acid dissolved in 2.25 liters of water. The room should be tightly closed, and, owing to the very poisonous nature of the gas, arrangements should be devised so that the chemicals may be mixed after the operator has left the room. Moreover, devices should be used for the thorough airing of the house before it is entered by human beings. The time of exposure should be about twenty-five hours, and an equal time should be given for airing. It is effective against all forms of animal life.

Danysz's Bacillus.—Danysz attempted to exterminate rats by means of a cocco-bacillus resembling the *Bacillus typhi murium,* which is pathologic for mice. He isolated this organism from an epidemic among field-mice, and by intensifying the virulence, obtained cultures that when distributed upon bread were said to be successful in destroying large numbers of rats in sewers, in shops and on farms. Investigations by other observers, however, indicate the total inefficacy of this method as a practical measure for the purpose designed.

In the presence of plague, not only should living rats be exterminated, but the bodies of dead rats should promptly be burned. It is a current belief in countries where plague is endemic that contact with a dead rat will produce the disease. It is also noteworthy that fleas tend to leave the body of an animal when it dies, thus menacing the health of persons or animals in the neighborhood.

The Destruction of Rabid Animals.

Dogs, cats, horses, hogs, cattle, wolves and other lower animals that show symptoms of rabies should at once be securely confined, or if the evidence of the existence of the disease be clear, killed. In dogs the incubation period of rabies is variable, eight weeks being about the average time. The disease usually begins by a stage of depression with lost or perverted appetite, followed by a stage of excitation or madness in which the animal utters hoarse howls and attempts to run hither and thither, biting at every animal that may come in his way. After three or four days depression and paralysis occur, the mouth drips bloody, foamy saliva and death follows. In about one-fifth of the affected dogs there is not excitation, but a condition of weakness followed by paralysis (*paralytic form*) and death. Should a person be bitten it is of utmost importance to positively ascertain the presence or absence of rabies in the animal inflicting the bite, as this determines the necessity of using the Pasteur inoculations. Thanks to Van Gehucten and Nelis, who have shown that rabies is associated with quite destructive changes in the peripheral ganglia of the cerebrospinal and sympathetic system, this may be determined within six hours. The head and neck of the animal should be removed, packed in ice and dispatched to a pathological laboratory for microscopic examination of the pneumogastric ganglia. The virus of rabies causes a proliferation of the layer of endothelial cells lining the capsules and finally their destruction and replacement by round cells. Care should be taken that these changes be not confused with somewhat similar ones that result from certain other causes. Ravenel reports over 50 examinations without a failure. The ganglia may be hardened in alcohol or a 4-per-cent. aqueous solution of formaldehyde gas, embedded in paraffin or colloidin, sectioned, stained by hematoxylin and eosin and then studied. If practicable, the animal should be permitted to die of the disease, as the changes are then most characteristic. This rapid examination is sufficient to determine the necessity of treatment, but it is wise to confirm it by inoculating a portion of the medulla of the suspected animal under the dura of a rabbit. If rabies be present the inoculated animal will develop the disease in from 12 to 15 days. If the study of the ganglia indicates rabies, all lower animals that may have been bitten had best be promptly killed, or if very valuable, incarcerated, muzzled and given the prophylactic treatment.

CHAPTER XV.

THE INHIBITION OF THE FACTORS OF DISEASE.

THE PRODUCTION OF IMMUNITY.

IMMUNITY.

The introduction of living parasites into the animal body may determine distinct reactive perturbations; such as alterations in temperature, nervous phenomena, cellular degenerations or other changes, in which case the animal is said to be *infected;* or it may show no recognizable reactions, whereupon the animal is declared to be *insusceptible* or *immune.* The distinction between susceptibility and immunity is not sharp and, in general, when the animal shows but slight functional or structural reaction to the entrance of a pathogenic organism, it is said to possess immunity. The condition is a relative one and necessarily involves two factors: (1) *The virulence and number of the invading parasites,* and (2) *The resistance of the invaded tissues.* Although for convenience these factors are considered separately, it must be borne in mind that practically they are always combined.

Virulence.

Bacteria are subject to wide alterations in virulence. Forms that have caused serious diseases may, within a few days, by the action of the unfavorable influence of heat, light, dessication, special nutriment or other agency, become relatively innocuous. Thus, the bacteriologist has difficulty in maintaining the virulence of such pathologic organisms as the pneumococcus, streptococcus pyogenes and bacillus of plague. To maintain their virulence he continues their growth in the bodies of susceptible living animals. Conversely, bacteria of feeble pathogenic power may acquire intense virulence in the animal body. For this reason necropsies upon those dead of septic infection are especially dangerous. The microorganism has become habituated to the defenses of the body and has acquired the power to overcome them. Thus, from the lodgment of a streptococcus of feeble virulence into a sebaceous follicle of persons with poor resistance, a furuncle may result. A scratch of the knife that opens the furuncle may cause a serious phlegmonous inflammation in a healthy person, while should the surgeon accidentally inoculate himself from this phlegmon he may acquire a serious or even fatal septicemia or pyemia, a result of the action of a streptococcus that some generations back was unable to affect his tissues. Many bacteria including *Bacillus tuberculosis, Bacillus anthracis* and *Bacillus typhosus* have degrees of virulence that are more constant and yet they are subject to wide variations. For example, different cultures of tubercle bacilli secured from different species of animals, from different individuals of the same species or even from different organs of the same individual may vary greatly in virulence. Thus, bacilli isolated from bodies dead of general miliary tuberculosis have been found far more virulent than those secured from "scrofulous" glands. No species of the larger lower animals, neither mammal, reptile, bird or fish, is known, but what has been found susceptible to some variety of the tubercle bacillus. So by analogy we conceive that certain types of tubercle bacilli exist against which no man is immune. As a rule, bacteria acquire virulence against a particular species of animal by living in a related, but susceptible species, or upon a medium approximating in composition the tissues of the particular species. It is important, therefore, that infections by bacteria virulent in man be exterminated from the higher species of mammals, and that efficient measures of disinfection be enforced in treating even apparently trivial infections.

Number.

The results of bacterial invasion may be influenced by the number of microorganisms introduced. Two or three virulent anthrax bacilli may have no effect on the susceptible guinea-pig, while a somewhat larger number determines a rapidly fatal disease. Watson Cheyne found that while the subcutaneous injection of 5,000,000 of

Bacillus proteus vulgaris produce no lesion, a larger number causes an abscess, a still larger number a phlegmon, while a much larger number of the bacilli determines death within 36 hours. As has previously been indicated, these results are modified by the virulence and avenue of entrance of the bacteria.

Symbiosis.

The virulence of a microorganism may be increased or decreased by association with other bacteria. Thus, the tetanus bacillus in pure culture may be unable to affect the organism, while in association with certain oxygen absorbing bacteria it is able to cause the death of the animal. The death of guinea-pigs follows more rapidly from injection of the anthrax bacillus when the otherwise harmless *Bacillus prodigiosus* is associated. These associated bacteria seem to divert some of the resisting agents of the body from the virulent organisms. Thus it may be that while the leucocytes are engaged in disposing of the associated saprophytes the pathogenic organisms invade the tissues. Combinations with apparently inert powders such as carmin may likewise favor infection.

Mixed Infection.

In tuberculosis, death is often not the direct result of the activities of tubercle bacilli, but is brought about by the secondary invasion of pyogenic organisms. The action of the bacteria of measles, pneumonia and influenza seems to favor the secondary invasion of the tubercle bacillus. At times association or secondary infection is of use. Thus the pannus resulting from trachoma may partially disappear after inoculating pus from an eye with mild purulent ophthalmia. An erysipelatous attack may favorably influence the course of lupus as well as certain sarcomata. The course of malignant pustule is said to be restrained by an associated infection with the pus-forming cocci.

Tissue Resistance.

Many factors influence an animal's susceptibility to the action of pathogenic organisms. First of all, certain families or species have an inborn resistance to certain forms of infection. This is termed *natural immunity*. The Chinese and Japanese, for example, are relatively immune to scarlatina, the negro shows a resistance to malaria and yellow fever. Man is immune to symptomatic anthrax and hog-cholera. The white rat is insusceptible to anthrax, while the house rat succumbs. Likewise, Algerian sheep and frogs are immune to anthrax, while the ordinary herds of sheep and toads contract the infection.

Most races enjoy a partial immunity to measles, while certain savage tribes, as the natives of the Faroe Islands, are very susceptible, so that among them it has a high mortality. When brought to civilized centres, Indians and Eskimos are prone to soon develop a fatal form of tuberculosis. Likewise, in certain families there seems to exist a relative susceptibility to tuberculosis. Besides inherited defects, the normal resistance of the tissues to infection is reduced by food imperfect in quality or quantity, the use of alcohol, chloral, chloroform or other drugs, overwork, trauma, and by the presence of certain other diseases. All of these effects have been shown not only by clinical observations, but also by experimentation upon the lower animals. Trauma may determine the localization of the tubercle bacillus, and diabetes favor its invasion of the tissues.

Exposure to heat, cold and dampness reduces resistance, hence the familiar expression "taking cold." The Samoans when they went unclothed were comparatively healthy. Their skins wet by passing showers, soon dried. Now their clothing when wet keeps their bodies damp for a considerable time and pneumonia, tuberculosis and other respiratory disorders are prevalent.

The relation of age to disease has already been considered. Certain infections pick out actively growing or functionating organs. For example, tuberculosis in children frequently attacks growing bones, rheumatism often affects the muscles most used.

Acquired Immunity.

It has long been known that after recovery from smallpox, yellow fever, scarlatina, measles or many other infections, the body is usually immune against the particular malady. How the body recovers, and why it remains immune, has been the subject of much speculation and experimentation. The older theories of *exhaustion* of some substance essential to bacterial growth or the *retention* of some substance inimical to their life, were displaced by the theory of *phagocytosis*—that certain ameboid cells, especially the leucocytes devoured the invading bacteria. That certain leucocytes do take bacteria within their substance has amply been proved, but that this constitutes the chief defense against infection has not been substantiated. Leucocytes that have failed to destroy bacteria may even serve to diffuse them through the body.

The bacteriolysins and antitoxins upon which we base our present conception of immunity have already been considered. It remains for us to describe how they may be artificially brought into use in the prevention of disease. Artificial immunity is termed *Active Immunity* when it is developed entirely within the body of the animal possessing it, and *Passive Immunity* when it has been developed within the body of another animal, and is acquired, in part at least, by simple transference. Active immunity is of slower development, but is much more persistent than passive immunity. Both are, as a rule, specific forms of resistance, protecting only against a single form of infection. Active immunity may be considered as a form of *prophylactic infection* or *prophylactic intoxication*. It may artificially be produced by introducing into the animal's body

1. Sublethal doses of virulent virus.
2. Attenuated or modified virus.
3. Dead bodies of bacteria.
4. Extractions from bacterial cultures.

Those forms produced by the injection of the living or dead bacterial bodies result in *lysogenic* types of immunity, while those produced by the introduction of bacterial toxins are characterized by the appearance of antitoxin in the blood. The first may be designated as an *anti-infectious* form of *immunity*, the second as *antitoxic* form of immunity.

Virulent Infection.

The Chinese 3,000 years ago are said to have practiced the introduction of crusts from variolous patients into the nostrils of children, that they might acquire smallpox and thus possess future immunity against the dread disease. This led to the practice of inoculation that spread to Persia and finally to Turkey.

Early in the eighteenth century Mary Wortley Montague, wife of the British Ambassador of Constantinople, wrote from Adrianople a letter containing this celebrated paragraph: "Every year thousands undergo this operation (inoculation with variolous matter), and the British Ambassador says pleasantly that they take the smallpox here by way of diversion, as they take the waters in other countries. There is no example of any having died of it, and you may believe I am satisfied of the safety of their experiment, since I intend to try it on my dear little son."

This led to a rather extensive adoption in England, and finally in America, of the practice of direct inoculation of variolous material into well persons. Objections to the method were that it produced a disease from which one might contract virulent smallpox, while in a small proportion (about 0.3 per cent.) of cases a fatal result followed. It was finally abolished (in 1840) by law in England. At present virulent virus is not employed in human practice.

Forms of Attenuated Virus.—A number of these were introduced by Pasteur. The method of attenuating the virus may consist of:

a. *Growth in the Body of a Resistant Animal.* Variolous matter introduced into the body of the cow may be transformed into the local and comparatively harmless affection *vaccinia.* Upon reintroducing this into man, it is found to have been permanently reduced in virulence. In 1796 Jenner deliberately infected a human being with the virus of cow-pox, as a preventive measure against variola. The efficacy of this procedure was proved by repeatedly inoculating the vaccinated lad with matter from smallpox pustules. In all, twenty inoculations with variolous matter were tried and all failed. Vaccination with cowpox was introduced into the United States in 1800 by Waterhouse ("the American Jenner"), who first vaccinated his own children and then proved their immunity by having them exposed in a pest hospital and inoculated with the virus of smallpox. He enlisted the active support of President Jefferson. The utility of this preventive measure has been overwhelmingly demonstrated by a century's use.

b. *Drying the Virus.* This is the method adopted by Pasteur in prophylactic inoculation against rabies. Pasteur found that in rabbits dead of hydrophobia, the spinal cord was especially virulent, but if the cord were dried, the virulence progressively diminished until at the end of ten days emulsions of the cord were found to be comparatively harmless. In practice it is found possible to create immunity after a person has been bitten and before the disease develops. About two grams of an emulsion of cord dried from 7 to 10 days is first used. The injections are repeated each day, using the same dose but an emulsion from a more recent cord, until on the 25th day the emulsion used is made from a cord dried only three days, whereupon immunity is considered to have been developed. For bites about the face a more rapid, intensive form of treatment is employed. The mortality of persons bitten by rabid animals, that receive these prophylactic injections is usually less than one-half of one per cent.

c. *Heating the Virus.* Many pathogenic bacteria when exposed to heat, diminish in virulence before the lethal temperature is reached. With certain bacteria, notably the anthrax bacillus, a persistent reduction in virulence may thus be obtained. Upon this principle, as elaborated by Pasteur, depends the manufacture and use of the anthrax vaccine. By growing the organism for fourteen days at a temperature of 42°-43° C. (107.6°-109.4° F.) a culture of slight virulence is produced. For practical purposes, two or three cultures of different strengths attenuated in this way are usually employed, being designated as vaccines 1, 2 and 3. These have a graded virulence, No. 3, being the most powerful. The animal is first injected with No. 1, later with No. 2 and finally with No. 3; about 1 c.c. of a well-grown bouillon culture being used at each dose. This method has been chiefly employed in protecting cattle, but owing to the difficulty in "rounding up" large herds of cattle three times, two injections are often supplied by manufacturers instead of three. As anthrax in man is an avoidable disease, this method is not employed in human medicine.

The prophylactic injection against *blackleg* (symptomatic anthrax) is made of the powdered muscular tissue of a diseased calf in which the spores have been attenuated by drying at a temperature of from 85° C. to 104° C.

Haffkine's prophylactic against *cholera* consisted of first injecting cultures of cholera bacilli attenuated by growing in a current of air at 39° C. and subsequently injecting a portion of a virulent culture. Later Haffkine found it possible to omit the preliminary use of attenuated virus. Apparently a distinct protection against cholera is conveyed to man by these inoculations.

The virulence of bacteria may be also reduced by exposure to *light,* to certain *chemical substances,* to *different species* of bacteria, to *electricity* or by development upon certain *unfavorable media.*

d. *Dead Bodies of Virulent Bacteria.*—This method of inducing an active immunity has been chiefly employed for the prevention of plague by Haffkine and others. The bacilli of plague are grown in massive culture, usually upon agar-agar or bouillon. They are then killed by a temperature of 70° C. (158° F.) for one hour. From 1 to 3 c.c. of the bouillon culture is used as a prophylactic injection. While not an absolute preventative, the method certainly seems to distinctly reduce the liability to contract pest. No unfavorable influence upon the general health of those inoculated has been observed.

Lustig and Galiotiti secured the nucleo proteid from the bodies of the bacteria by dissolving them in a one-per-cent. solution of caustic potash. This is acidulated and the washed precipitate dried and given in doses of about 3 milligrams. It seems to be less valuable than the prophylactic of Haffkine. To immunize against enteric fever, Wright uses 1 c.c. of a bouillon culture of typhoid bacilli sterilized by heat. The bacteria used may also be killed by chemical or other agents, but heat is chiefly employed because of its reliability and ease of management. Wright's prophylactic has been extensively used among the British troops in South Africa, and while not an absolute preventative, it seems to cause a partial immunity, so that an inoculated person, if he does not escape the disease, seems to have it in a milder form.

e. *Extractives from Bacterial Cultures.*—These have their chief value for the production of high grades of active immunity in animals, and in the manufacture of antitoxins. They are represented in *tuberculin, mallein* and the more recent *tuberculin O* and *tuberculin R* suggested by Koch. Tuberculin is a glycerin extract, prepared by the long heating of massive bouillon cultures of tubercle bacilli in association with glycerin. Tuberculin O and tuberculin R are prepared by grinding the bacilli to fragments in a mortar, washing by adding distilled water, and precipitating the residue with a centrifuge. The tuberculin R is the sediment, tuberculin O the clear supernatant fluid which contains tuberculin. It is claimed that all of these substances have an immunizing power in the lower animals. They are scarcely to be advised in the prevention of tuberculosis in man, nor is their curative power in cases in which the disease is established sufficiently pronounced to justify their *indiscriminate* use.

In cases in which an active immunity is produced by one of the above methods, it is slow of development, but usually very persistent. Thus, the immunity derived from vaccination for *smallpox* persists for months, and often for many years. The slow development of the immunity renders vaccination, as a rule, of less value after inoculation with the disease against which its protection is directed. Thus, if a man becomes infected with smallpox and is promptly vaccinated, it is probable that vaccinia and variola will develop simultaneously and may run their course, each without special influence upon the other. In cases of *plague,* inoculation of Haffkine's prophylactic after the onset of the disease increases the jeopardy in which the patient lies, by adding to the sum total of toxic material against which his tissues struggle. A marked exception occurs in the case of rabies, for here so long a time intervenes between inoculation and the onset of the disease that time is afforded for the development of an immunity.

Passive Immunity.

If certain body-fluids or tissue extracts taken from an animal having a high grade of active immunity, be injected into a nonimmune animal, a degree of resistance may thus almost immediately be transferred to the second animal. If the active immunity of the first animal was developed by introducing the bodies of bacteria, the second animal will receive an *antimicrobic* or *bacteriolytic* form of immunity; while if the active immunity of the first is a result of the use of bacterial toxins, antitoxic form of immunity will be imparted. That is, in the former case the animal will resist the growth of the bacteria in its body, although it may have comparatively little resistance to their toxic products; while in the latter case it will resist the effect of the toxins, although having little action against the bacteria themselves. As blood-serum is the most convenient substance for the transfer of the immunity, the terms *antitoxic* and *antimicrobic* serums have come into use. Both properties are usually present, the one predominating over the other; and of the two, the antitoxic serums have thus far been most valuable. The serum from animals artificially immunized have so much greater power than that from animals naturally immune as to be universally employed. Moreover, their use is much safer and induces much less discomfort than that of various forms of inoculation. Unfortunately, the immunity produced is quite transient, the immunizing substance being soon eliminated from the body, leaving the latter as susceptible as before. In diphtheria the immunity is known to last about thirty days in man; and if a longer immunity be desired, the injection of diphtheria antitoxin must be repeated. The exact immunizing dose is not known, but it is always safe to use a quantity in excess of that believed to be required. Five hundred units may be taken as an average safe amount for a child. The very great value of this remedy as a prophylactic has been shown in children's hospitals, where by its use, epidemics have quickly been arrested. The tetanus antitoxin is undoubtedly much more valuable as a prophylactic than as a curative agent, but it is so difficult to determine when a person has been inoculated with the bacillus of tetanus that it is rarely employed. In cases of punctured wounds it should be more frequently used. Unfortunately, it is not very stable.

These serums have chiefly been employed for purposes of treatment rather than prophylaxis. Yersin and Lustig have prepared antitoxic serums against plague, by the immunization of horses. That of Yersin seems the more potent. Shiga's antitoxin has proved of value in the treatment of dysentery. The antitoxin derived through action of the pneumococcus, streptococcus and tubercle bacillus, have thus far given conflicting or disappointing results. In the development of the lysins, it is hoped that methods of artificial immunization of wider scope and greater potency will be developed. It should be obvious, however, that methods of artificial immunization will never enable human beings to dispense with the observance of general hygienic precautions. They are specific and protect against single diseases; appropriate food, exercise, sunshine and baths have a general immunizing effect and increase the resistance of the tissues to all disorders.

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THE MEDICAL INSPECTION OF SCHOOLS: A PROBLEM IN PREVENTIVE MEDICINE.*

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As preventive medicine, when viewed in its broad, general sense, indicates not only the prevention of disease and its consequences to the individual, but of still greater import to the mass of people; so does the medical inspection of schools primarily concern itself with the individual and thereby occupies a deserving place in the efforts being made to eliminate disease and conserve health and also in a far reaching way, it embraces the betterment of the masses both in its hygienic and economic aspects.

Daily medical inspection of schools, and this especially is what is desired to emphasize here in contradistinction to occasional inspection, was successfully inaugurated in Boston in 1894 as the result of an unusual prevalence of diphtheria. The success obtained from this experience and the agitation that had been promulgated for several years previous, began to have its influence on the health and educational boards of other cities, with the result that various degrees of inspection of school children was authorized in New York City, Chicago, Orange (N. J.), Philadelphia, Newton and Brookline (Mass.), Jersey City, Asbury Park, Milwaukee, Minneapolis, Salt Lake

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City and Cleveland. In Boston when this measure against disease was first instituted, the city was divided into 50 school districts and an equal number of physicians were appointed so that each would visit daily a single district. But a few months after Boston had inaugurated this work, Brookline appointed six inspectors and four substitutes, while Newton appointed physicians for each district to examine the children in school or elsewhere in the event of suspected disease. Although agitation was vigorously continued in other places by those who realized the immense benefits to be derived by this phase of preventive medicine, no results were obtained until 1895 when Chicago was for this purpose divided into nine districts with one medical inspector assigned to each, thus giving each inspector about 30 schools. In New York City medical inspectors were first appointed for the public schools on March 16, 1897, and 134 physicians were selected to visit the schools daily, while in Philadelphia and elsewhere it was not until 1898 that further results were secured. It may also be mentioned here that while medical inspection is of comparatively recent date in this country, in Paris a form of inspection was carried out in 1833, while the laws of 1842 ordered that all public schools should be visited by a physician who, in addition to inspecting the buildings, should also inspect the general health of the school children. Since then the system has several times been reorganized in order to improve its efficiency and has been of such value that it has been used as a model for similar hygienic work in all other French cities. While owing to its unqualified success, the school law of 1886 and the ministerial decrees and orders of 1887, have made medical and sanitary inspection obligatory for all the schools both public and private.

Before entering more fully into the details of medical inspection of schools, a clearer comprehension of what is being done in the various municipalities at present having this system in part or whole, will enable one to obtain a better view of the question as it at present stands. In Brookline the school department cooperates with the Board of Health and all the public schools are inspected daily or less frequently, depending upon the amount of disease present. During varying intervals when the town is entirely free from contagious diseases, the inspection may be temporarily suspended, but such a system while having its pecuniary advantages in a small town when contagious diseases may be entirely in abeyance at irregular intervals, cannot be of much value in a large center of population where diphtheria, scarlet fever, etc., are always present to a greater or lesser extent. The inspection in practically all of the places where it is carried out by a number of inspectors, is made during the early school hours preferably between 9 and 10 A.M. and the teacher in charge of each room refers the pupils who present symptoms of illness to the inspector, who occupies a separate room where the children are examined and a diagnosis is made. In case of contagious disease being discovered the child is immediately sent home with an explanatory card advising the parents to call in their family physician, while in non-contagious diseases depending upon their nature the teacher is directed to retain the child in the class and to later advise the parents that the child requires medical attention, or in event of the child being too ill to remain, it is sent home with a card to that effect. Depending upon the distance between the schools an inspector may have one or several to visit daily, this of course differing dependent upon the local conditions in various cities. In Minneapolis the system is a volunteer one and has been in operation for less than a year, but it has been very satisfactory and the inspectors make a weekly report to the chief inspector, who in turn issues a monthly report. In ordinary cases the pupil is sent home with a blank which states to the parents that the child appears to be ill, while in contagious diseases a special postal in addition giving the name, address, diagnosis, etc., is mailed to the Department of Health, thus placing the child under early quarantine, which, without the detection of the disease by the school inspector, would not have been the case and in many instances preventing the infection of other pupils. In Newton where daily inspection is being seriously contemplated, the pupils are examined as regards the presence of illness only at the beginning of school after a vacation, but this of course has little value and while it may succeed in detecting some cases of illness that appear at school at such times, it in no way fulfils any practical service towards the prevention of contagious diseases.

In Philadelphia daily inspection is under the administration of the Board of Education, 200 volunteer inspectors visiting the schools daily before 10 A.M., and as a result of the first year's volunteer work, over 5,000 pupils requiring medical attention were found and referred to their family physicians. The usual system of ordinary and special diagnosis cards are used and the principal of the school to whom the children with any ailment are referred, fills out a blank for the child to take to its parents from the diagnosis card furnished him by the inspector. The Educational Board observes the laws of the Board of Health in regard to dangerous, contagious or infectious diseases such as cholera, smallpox, diphtheria, diphtheritic croup, membraneous croup, scarlet fever, typhoid fever, typhus fever, yellow fever, epidemic cerebro-spinal fever, etc., and in such cases a special card is furnished which is immediately mailed to the health authorities, while the child is sent home at once. While in cases where whooping-cough, measles, chicken pox, skin diseases, mumps or other ailments which are not mentioned in the "dangerous" list are found present, the ordinary diagnosis card is filled out and the principal of the school is notified that the child cannot return until a physician certifies a cure. At the end of each month the head of the school sends a report of the diagnosis cards to the Board of Education with the name of the pupil, residence, age and diagnosis placed upon it. The system in Philadelphia, if properly carried out, as in New York, Boston and a few other places, would do much toward reducing the prevalence of contagious diseases, but for want of appropriations the inspectors after two years' work with no leader nor compensation, have gradually dropped their appointments until at present not more than 10 per cent. are visiting the schools and the present status of daily medical inspection in this city is one of masterly inactivity.

Boston and New York City at present undoubtedly lead in the care exercised by these respective municipalities over the health of the school children. The former city has probably the best system in use to-day and with an efficient corps of some 50 inspectors, material results are being obtained in this field of preventive medicine. This is well shown in the work accomplished in 1900, when of 15,573 pupils examined in the schools, 3,055 were sent home for various diseases and many physical defects were by this means eradicated which had otherwise retarded the work of the individual and had seriously impeded their full mental and physical development. The inspectors are also authorized agents of the Board of Health and in addition to visiting the public schools daily to examine all sick pupils and to advise the teacher concerning them, they also decide questions concerning the attendance of such children as live within the same building in which there is a case of contagious disease and in addition they visit every case of diphtheria, membranous croup and scarlet fever reported, to ascertain the effectiveness of the isolation. In New York City the division of medical inspection is also under the Sanitary Bureau of the Department of Health, with an efficient corps of about 250 inspectors and daily reports are made to the Chief Inspector who in turn presents a detailed weekly report to the assistant Sanitary Superintendant. Not only are the public schools subjected to the daily examination of the pupils, but so also are the parochial, tenement schools and various societies where children are daily grouped together. The blanks used to report contagious or non-contagious diseases do not differ in any essential respect from those previously mentioned, but in suspicious cases cultures are taken and in all cases where the throat is examined, individual wooden tongue depressors are used which are then destroyed; a matter apparently trifling in itself, but one of much import in preventing the transmissions of diphtheria or more rarely syphilis.

At Asbury Park the medical inspector visits the school each day at 10 A.M. and ascertains the nature of the illness present in such pupils as have been referred to him by the teachers, each child bearing a blank from the teacher containing in addition to its name, age, etc., the query as to the presence of sickness at home and the symptoms noted by the teacher which have directed her attention to the indisposition of the pupil. If the illness be of sufficient import, the child is sent home with a blank stating that it is ill and should be placed under the care of the family physician and later when he returns to school, a physician's certificate showing that recovery has occurred should be furnished. In addition to this a valuable record is kept of the individual, showing his name, age, class, weight, height, general condition, chest measurements, spine, cutaneous diseases, heart, lungs, nose, throat, teeth, eyes and ears; this is placed in an index so that the physical condition of the pupil can be readily ascertained in a few moments. Jersey City is divided into districts and each physician visits the schools in his assigned district twice a week, the sanitary condition is noted in addition to the detection of any apparent illness among the scholars and a postal report is made to the health board. Of course as regards the pupils this is but a partial inspection and to a slight degree only fulfils the conditions aimed at in the daily observation of the school children. Somewhat similar has been the work in Cleveland but the object here seems to be aimed along general lines of school hygiene as regards the physical surroundings of the pupils and is not essentially concerned with what is presented in this paper.

Wherever a school house is located, a field is at hand for the practice of medical inspection and as the subject is one of no limited extent, but as broad and as far reaching as the existence of disease, so must every individual professional or layman, have some interest ultimately in anything which will aid in preventing the sickness of the child or in avoiding its contact with another having a communicable disease. According to the last census there are in the United States 26,110,788 persons of school age, that is between five and twenty years and while the various States have a multiplicity of laws regarding the so-called school age, yet 21,573,492 of these individuals are between the ages of five and seventeen years. Not all of these however go to school and all do not therefore enter into this phase of the question, but according to Kober there were in the common schools for the year ending June 30, 1900, 15,341,220 children, surely a sufficient number to cause some concern to be taken in regard to their physical condition. Yet as an actual fact, but an infinitesimal number of these 15,000,000 individuals, who spend the greater part of their time in school, receive municipal or State recognition for the demand of their physical condition, either to maintain their normal health or to prevent the dissemination of disease, as a routine measure but only are efforts made in the face of endemics or epidemics. The acute infectious diseases as diphtheria and scarlet fever, are especially prominent during the years at which the child spends the greater part of its time in school, while other communicable diseases as whooping-cough, measles and contagious skin diseases also occupy a similar relation in regard to their usual appearance during childhood or adolescence. While the school can hardly be accused of being in itself the cause of any of these diseases, yet no one can deny that it is a patent factor in their propagation and undoubtedly under many conditions found in the schools a train of physical ills are consequent that seem to be the price the child must pay for its education. It has been well said that "the object of the public schools is to train to good citizenship," yet one must doubt very much if the defective or the adult with the sequelæ of diphtheria or scarlet fever contracted from his schoolmate in boyhood, can do the work he is capable of when partially disabled by ill health, defective sight or impaired hearing, yet thousands of children are at school often under

State laws compelling them to be there, trying to prepare for their future under physical impairments that their parents, were they in like position, would consider insurmountable.

The health of school children is a wide and complex problem, because all children during certain ages are at one time or another in school. It has only been recognized within recent years that the State owes more to the child, more to itself, than a mental education to a greater or lesser degree. Even now this is not fully recognized and in the majority of public schools under existing systems where no attention is paid to the pupils individual physical welfare, nor any attempt is made to recognize the presence of disease which careless parents neglect to observe at home, many hundreds, even thousands of lives are sacrificed annually and numerous others bear the scars of the educational fray till their life-work is over. A. K. Whitcomb states this succinctly when he says a phase of the subject which has been attracting widespread attention in recent years, has been the study of children physically defective. Tests in this country and Europe have shown a startling prevalence of defects which have been unsuspected by either child or parent. School children are of a susceptible age not only as regards their liability to contract contagious diseases, but to a marked extent to structural deviations from the normal, so common during this the formative stage. This is especially marked in girls and notably so in the high schools, a recent series of papers by Lovett and others showing this clearly, and the conclusions that girls are not as well on the average when they leave school as when they enter, seems to be borne out by actual facts. I am sure no one can go into a public school and not find at least one and often more scholars requiring medical attention. Spratling in a class of 40 pupils in Springfield (Mass.), found two consumptives, an epileptic, three with inherited syphilis, a typical moral degenerate and many suffering from defects of the teeth, tonsils and ears. It has been estimated that 11 per cent. of the public school children are unfitted to enter into competition with their healthy fellows and as these require education the same as the non-defective, medical inspection provides a means by which this large number may be materially reduced.

While but comparatively desultory investigations have been made in this country of the health of school children, yet considerable scientific work along this line has been done abroad. It is impracticable here to give details from foreign investigators of the influence of school life upon the health of the children, but it is desired to mention certain facts which have a practical bearing upon elucidating the value of competent medical inspection as but one of several hygienic measures directed towards increasing the mental and physical efficiency of the school child. In all 104,629 school children were investigated by various observers and it was found that there was a surprising amount of ill health especially among girls. Eliminating accidental or acute illness and myopia, the morbidity varied from 20 to 61.7 per cent., the latter in Stockholm among girls. While the morbidity of school children has been fairly well ascertained the question of mortality presents an entirely different aspect and practically embraces the mortality of youth in general, which of course cannot be applied to the results of school life upon the child. From careful studies made however by Chalmers of Glasgow, a great improvement has been effected in the health of school children during the past twenty years. The decrease in the death-rate of individuals from five to fifteen years of age amounting to about 38 per cent. in the time specified; which is equivalent in Scotland to an annual saving of 2,696 lives out of every million of school age. The result of the adoption of hygienic measures especially as regards medical inspection, is also shown by its effect upon the reduction of the mortality, for as a result of this inspection in Chicago, the mortality of diphtheria for the months of September and October, 1900, had been materially reduced, there being 42 and 77 deaths respectively for this year, while for the two similar months for a number of years the mortality was 85 and 127 respectively. While the report of the Massachusetts State Board of Health for 1896, shows that there were 72 fewer deaths from diphtheria than in 1895, although the number of cases reported was largely increased on account of the large number discovered among the pupils in the public schools by the medical inspectors and the bacteriological tests in the otherwise unrecognizable cases. The ratio of deaths to the number of cases reported was 11.48 as against 14.48 per cent. the preceding year. As before mentioned little scientific investigation has been done in this country to ascertain such relations to the health of the pupil, but in Sweden it was found that the morbidity was 5.3 per cent. higher in those who worked over the average time and in Denmark it was 7 per cent.

While the majority of communicable diseases incident to child life occur in the public schools as the result of bringing a number of individuals into daily, close contact for several hours at a time, yet there are a number of diseases which seem in their development to bear a close relationship to school attendance and which therefore may be grouped under the title of school diseases, *or preferably* diseases incident to school life.

These may be grouped as those of the special senses especially refractive errors and to a much less extent various affections of the ears. Many cases of curvature of the spine are also assignable to this cause and nervous affections are common especially headache, insomnia, minor grades of chorea, etc. Affections especially of the upper respiratory tract undoubtedly have a near relationship to school attendance, while general infectious diseases, parasitic diseases and contagious diseases of the skin and eyes have in some repects a close affiliation. Neurasthenia or various nervous disorders are especially common among school children and near the close of each term of school, it is the experience of almost every practitioner to see a number of cases especially in girls of the higher grades, where physical breakdown is the result of the close mental application during the school term. Practically school diseases embrace all diseases to which children are heir, but two classes are especially applicable to the subject as considered here, the first being those affections which are the result of the school work or which are aggravated under these conditions, while the second class which has of late attracted the most attention, are the communicable diseases which may or may not be of a dangerous character. No one can doubt the deleterious effect produced by ill-health upon the capacity of the pupil for study and numerous instances might be related to show the failures made not only while the child was at school but even extending into later life, by unrecognized physical defects which could be repaired in time making a useful child instead of one only partially so, if some attention had been paid to his physical condition as is done in those schools where medical inspection is part of the daily procedure. A. K. Whitcomb gives a striking example of this in a boy of five, who attended school a half year without learning a single letter, finally after this time had been wasted it was found that he was so astigmatic that it was impossible for him to see a letter, while remedy of the defect showed him to be as competent as the other children.

As "the aim of an education must ever be the development of the fullest and soundest mental, moral and physical life of which the particular individual is capable," the question of ascertaining and caring for those not able to come up to the normal must also be seriously considered. Again the medical inspector may be of value in directing attention to those who are nervous, delicate or defective to a greater degree than will allow them to remain in a large class with the other pupils and the results of segregating this class of individuals small though it may be, are most encouraging. To a limited extent this has already been done in Philadelphia and as a result the school for backward children has developed, which has been of great value in educating these individuals who have heretofore remained in statu quo in the regular public school. Medical inspection has already in the few years of its existence done much for this small but constantly increasing group of unfortunates, to whom the state owes an education but who are individually incapable of receiving it when placed in close competition with the normal child. The question of handling these defectives is a serious and a large one and except for their detection in the school and recommendation to their parents and teachers as to what should be done for them, bears no close relation to medical inspection per se.

In order to more clearly establish the cogent reasons for the wider recognition of medical inspection, one has to consider as but one of many reasons advanced, the effect of disease upon the future career; while of course medical inspection will not abolish disease among school children, yet it certainly will materially reduce the prevalence of the so-called school diseases and also reduce to a minimum the dangers of contracting contagious diseases. Physical defects among the pupils of the public schools are strikingly common, so much so, that this may well be made a dogmatic statement. In Newark during the first five months of inspection out of 5,585 children examined, 1,706 were excluded from school, the great majority on account of communicable diseases. In 10 months in Philadelphia 3,446 contagious and 2,430 non-contagious affections were observed, while Boston inspectors found in one year 4,023 cases of contagious and infectious diseases and for the year 1900 out of 15,573 school children examined, but 4,952 were found free from disease. Surely a remarkable showing, but one which can be found from time to time in the majority of schools in the larger cities.

While it is not possible to entirely eliminate all disease from the school, yet the mitigation, cure or better still the prevention of many of these physical defects is entirely within our reach. The defects all have a remedy and if the medical inspection of schools had its value fully impressed upon those in authority, more substantial gains would be made in the near future than have been made in the past in the dozen or so towns where this has been in more or less effective force. Regular and daily systematic medical examination by the physician is a demand made by the modern recognition of preventive medicine and its full significance is becoming more widely appreciated as it's results become more apparent. Medical inspection means that the pupil and not only the educational system is being considered and its objects embrace a two fold measure, first, to reveal and correct insanitary conditions existing in the school which may act as predisposing or exciting causes of disease, and secondly, its functions are to detect disease and especially those of a contagious or infectious character. That the experience of those familiar with this subject has been unanimous in extoling its value not only in improving the hygienic surroundings of the school child, but in detecting many diseases which had otherwise remained undetected and especially in locating early cases of diphtheria, etc., certainly implies that it deserves the greatest attention. The value of inspection shows itself along numerous lines affecting the condition not only of the child but also the teacher, the parents and the community at large. It has proven to be an important factor in the education of children and especially their parents in matters relating to personal and home hygiene and it has directed the attention of health and school boards to improvements and reforms which before had not attracted attention. As stated by Kober it has proven of inestimable value and while figures show but a part of what has been done, yet the following give some idea of the prevalence of disease in the schools, which previous to medical inspection was entirely neglected or detected only after the illness was so marked that it was apparent to the parents.

In Boston, from November 1, 1894, to October 31, 1896, out of 23,207 pupils examined there were 6,571 cases of disease and of these, 5,818 were too ill to be in school. The total school population at that time being 83,303. In three months in New York 4,183 children were excluded from school on account of contagious diseases, out of 63,812 examined. During a period of four months in Chicago 233 public schools were visited by the inspectors with the result of finding 1,417 cases of diphtheria and 306 of scarlet fever, while at a later period in the same city out of a school population of 200,000, 76,805 were examined and 4,539 were found to be suffering from contagious diseases, necessitating their exclusion from school. Noticeable among the results obtained in those schools where medical inspection has been enforced, is the improvement in cleanliness of the children and it has been especially noticed that the parents are more apt to keep ill children at home where previously they were sent to school, thus giving earlier attention to the sick child and at the same time in case of contagious disease a greater degree of security is afforded to those children who are at school.

In order to have a successful system of medical inspection and to obtain the best results, organization is essential. While good results have been obtained where the inspectors are under the direct control of the board of education, yet the inspectors under such circumstances do not have the full legal control over some of the problems that are constantly presenting themselves and in order to insure the best results both for the children and the community at large, the inspectors should be banded together as a definite organization under the board of health. In other words the inspectors in case of contagious and infectious diseases should act as agents of the health board, with all the power of that board behind them, while in the case of other affections they can have but the power to recommend that the child requires treatment and if necessary should not be allowed to remain at school until it has had such treatment. If the system of inspection is contemplated in a small town one or two inspectors will be fully able to cover the field, while in a large city a number are required depending upon the number of schools, of scholars and the relative distance between the school buildings. In Salt Lake City and Cleveland a single inspector performs the duties, but this hardly embraces medical inspection to anything like a complete degree and in these cities more attention is paid to school hygiene and the examination of the eyes and ears of the scholars, while in Philadelphia under an incomplete system 200 physicians visited the schools daily. The number of inspectors in other places varying with the number of schools and the thoroughness with which the authorities desired the work to be carried out, New York having 250 inspectors; Boston about 50, Milwaukee 12 and Newark 12, while in the few other cities where inspection is carried out, the number varies considerably. In organizing a system of inspection, it is essential that there should be a Chief Inspector who should possess both the qualifications of physician and sanitarian and who also should act as an official of the health board. The inspectors should form an organization having for its objects the promotion of an esprit de corps; the discussion of subjects relating to the inspection of schools and the various measures to be employed in eliminating disease and insanitary conditions therefrom. Such an organization in Philadelphia was productive of an immense amount of good and the inspectors composing it published a report of the work done for a certain period of time in which it did much towards instructing the school authorities and the general public of the value of inspection. In Boston also, an inspectors' association has been formed and is presided over by the chairman of the Board of Health, while in addition to the subjects discussed as mentioned above, addresses by specialists are given from time to time on diseases of the eye, ear, nose, throat, etc.

The duties of the inspector commence with the time of his daily visit to the school; usually he is expected to make his morning visit between 9 and 10, thus giving the teacher time to note those who appear to be ill and have them ready for the medical examination when the inspector arrives. A partial or complete diagnosis if possible may be made of the various cases, but unless the disease is clearly of an infectious or contagious character, it is usually advisable to send the child home with the advice to the parents that it requires medical attention. In case the disease is infectious or contagious, the child should be sent home immediately; in case of doubt (diphtheria) a culture should be taken and in addition to notifying the parents, the proper health officers should also be advised promptly, either by postal as seems to be the method mostly in use or better by telephone. Under such circumstances if several cases are found he should visit the several class rooms in the school building, paying special attention to the one from which the suspected case or cases originated and examine every pupil, making cultures from those who present any evidences of sore throat. From time to time tests should be made for defects in sight or hearing and careful attention should be paid to pupils who present any evidences of ill health chronic or otherwise, or who by mouth breathing suggest nasopharyngeal trouble. Once a year at least, the inspector should examine all children irrespective of a physician's certificate, as to the presence or absence of a well-marked vaccination cicatrix, but under no circumstances should he suggest any treatment or in any way interfere with the family physician. Under the volunteer system which is usually first adopted as a trial measure, the inspectors can hardly be expected to perform more duties in the school than those mentioned, but when the inspectors are paid and act as agents of the board of health as should be the case, they should also visit the class room daily and inspect the surroundings as related to temperature, desks, toilet rooms, etc., and exercise in general a sanitary supervision over the school in all ways that relate to the health of the pupils. The inspector then recommending to the chief inspector the removal of such defects that may be found prejudicial. Acting as an agent of the board of health he should also visit cases of contagious diseases when the family physician reports their recovery and should raise the quarantine and furnish the permit to return to school, this of course being limited to contagious diseases, as he has no control over other diseases outside of the school. In addition to notifying at once the health authorities, the teacher and the parents of the presence of a contagious disease, he should also send to the chief inspector a daily report of all children excluded from school and a weekly report including a complete list of the pupils examined and of those presenting any evidence of disease.

Necessarily only the general principles involved in the duties of the inspectors can be mentioned here and in each city or town these must vary in detail to suit the conditions present. In New York for instance, the diagnosis of measles or scarlet fever made by the school inspector must be confirmed at the home of the child within 24 hours by one of the diagnosticians of the Board of Health; while in Boston the inspectors visit at least twice, every case of infectious disease in their district; decide when isolation may cease and for disinfecting the premises. In Chicago daily reports are made of all cases examined and excluded, both to the Superintendent of Compulsory Education who has control of the system of inspection and to the Commissioner of Health; while in emergencies as outbreaks of diphtheria, scarlet fever, smallpox, etc., the report is made immediately over the telephone. As the inspection has been made here with reference to transmissible diseases only, the pupils are referred to the inspector by the school principal for two causes, first, those with suspected contagious diseases and secondly, those who have been absent for four or more consecutive days. Children with severe attacks of tonsillitis are also excluded until culture shows a negative diagnosis and a very wise measure is in force requiring aseptic methods of examination to be employed.

The chief inspector who should undoubtedly be an official of the health board and also act in harmony with the educational board, should exercise a general supervision over the medical inspectors, should receive and file daily weekly or monthly reports from the inspectors and should report to the educational board with his recommendations, cases of various diseases and instances of faulty hygiene which come under his attention. In addition he must take an active part as a health officer in enforcing quarantine laws in contagious diseases and should in general exercise such functions as are common to the position of health officer with in addition, special authority as relating to the hygiene of the school and its diseases.

Where for erroneous arguments and lack of fiscal appropriations daily inspection is apparently not feasible, the inspections may be made biweekly or weekly as is done in Jersey City, or as in Salt Lake City where they have but a single inspector who investigates contagious diseases after they have been reported. Of course it is impossible for one man to exercise medical supervision over a large number of schools, but even by this method in lieu of a better, much good can be accomplished in detecting eye and ear defects and improving the general sanitary surroundings of the pupils. Again medical inspection of the schools may be made only at the beginning of each school term or session of school after a vacation, but this bears no relation to the results obtained by daily inspection and enables the inspector to detect ills that may be present at intervals too infrequent to be of value in combating communicable diseases. The results shown by irregular inspection in contradistinction to daily inspection, have been utilized and are of value in organizing preliminary investigations to determine whether a given place required daily inspection or not. One or more volunteers if possible depending upon the number of school children, will be usually sufficient to demonstrate the value of inspection and will be a great aid in paving the way for a permanent system. Such preliminary investigations as conducted in Chicago by nine inspectors of the health department for more or less regular periods of the school year and based upon physicians' notifications, located 4,023 cases of contagious and infectious diseases; 47,310 vaccinations or revaccinations were secured; an epidemic of impetigo contagiosa involving seven schools was arrested in a few weeks after excluding 107 cases and a vast number of ills and sanitary errors were detected by this small force, that immediately paved the way for the necessity of inspection as a definite part of the sanitary system of the city. Similar preliminary investigations were also made in New York and it was found on examining the list of children absent from school that many cases of diphtheria passed unnoticed, while such was also the case in scarlet fever though to a less degree. So convincing was the evidence accumulated especially in regard to early detection of contagious diseases and the suppression of incipient epidemics, that a chief inspector and a staff of 150 later increased to 250, were appointed as a necessary sanitary measure.

An important factor and one which while not especially concerned with contagious diseases but which is of much import to the individual, is the necessity for medical examination of the child on its first entrance to school. This does not imply that no future examinations should be made after the first at usually an early age, but the pupil should yearly be investigated in regard to the special senses and for any physical ailments that may be observed by the teacher from time to time. With such a basis as the first examination of which a record is preserved and added to from time to time as the child progresses in his school work, a decided advance will be made in preventive medicine. Usually the educational system determines the standing of a child by his mental powers alone, but such a method is in no wise fair to the individual or the state, as children bright mentally but with undiscovered physical defects make their way rapidly through the prescribed course, some to break down when partially through, while others complete their studies at the expense of their physical welfare and either require a long time to recuperate or always bear the result of their education as physical ills. Medical inspection has done much in a limited field to negative these harmful results and as its field broadens it will do much more, while if carried out so that special examinations are also made of new pupils, much will be done toward having the system fit the child and not the reverse as is commonly the case.

While nearly all the diseases common to childhood have been found in the schools by the investigator, yet any accurate statistics as to the proportion of ill school children to those healthy, seems to be unobtainable. Various estimates have been made from time to time but they are usually based upon observations made in foreign schools and relate more to defects of the special senses with trivial nervous disorders, with little regard to the important group of communicable diseases and therefore have but little value if applied to school diseases in this country. From medical examinations made in various American cities, it seems to me that a fair and safe estimate of morbidity in children at school and not children sick at home whose names are on the school list, would be about 10 per cent. Probably 11 per cent. are in school suffering from some physical defect or illness interfering with their work, while nine per cent. will be found not too high for those who are too ill to study and require medical treatment. Scattered reports obtained now and then from the cities where medical inspection exists would also seem to bear out the accuracy of these figures, while as bearing out this point the following figures are suggestive; 30,045 children were examined in Cleveland in 1899-1900 and 6,221 or 20.7 per cent. were found to have defective vision, while in a single school 23.5 per cent. of the pupils had defects of the special senses and the inspector of Malden found 200 pupils requiring medical attention out of 528 examined. The reports obtained at Boston are instructive in this connection as in one year 1,156 were found too ill to remain at school, out of 8,964 examined. In one week in New York, 195 cases of communicable diseases were found, another week 7,398 were examined and 364 were excluded, while for still another week out of 4,598 examined, 243 were too ill to remain at school and in the first three months of the inspection during which 63,812 pupils were investigated, it was found that six per cent. had to be excluded for contagious diseases. In Minneapolis out of 25,-

696 pupils examined 8,166 or 32 per cent. had defective eye sight; nine months examination in Philadelphia showed the presence of 5,876 cases of disease in the schools, of which 3,446 were contagious. Surely these figures imply that we do not have to go far to find foci of contagion when an active field is found in every school, without at all taking into consideration the large number of school children who have diseases not transmissible.

Probably the chief value of medical inspection is the immense service that it has rendered in checking the spread of contagious diseases and therefore preventing epidemics or endemics. It certainly stands to reason that there is much less danger of a child contracting diphtheria, scarlet fever or measles for instance if another child with any of these affections in close contact with it in school is immediately removed at the beginning of the morning session, instead of remaining for the better part of the day. Without medical inspection in some form, such a condition has in the past and must in the future inevitably exist until the ill child becomes so sick that attention is of necessity directed to it. With inspection, this most common method of transmitting diseases becomes to a great degree obsolete and an advance will necessarily be made in preventing epidemics of such diseases as are common to the school age. I believe we have no better single factor in preventive medicine both in its fullest sense in preventing disease and also in the early detection of a large and serious group of affections, than the adoption of this measure. It is a matter of daily occurrence to have a school closed here or there on occount of an endemic of diphtheria, etc., yet the detection of the first case which is usually in school, or whose brothers or sisters have attended school during the early stage or as does happen, during the better part of the course of the disease, is but necessary and the dangers are reduced to a minimum or entirely removed. In New York a marked check has been noted from time to time upon the spread of contagious diseases, while a committee of Philadelphia inspectors as a result of a year's daily experience in the schools, felt warranted in stating that epidemics have been averted by the early detection and exclusion of many of the cases and that large numbers of children have been saved from unnecessary illness by detaining from school the sick, the uncleanly and the vermin ridden. Arnold has probably demonstrated the value of medical inspection most clearly in its relation to epidemics, where in a class of 40 pupils, 14 were affected by diphtheria and four children in the families of these were also affected. As soon as the epidemic was recognized four suspicious cases were sent home and recommended to the care of the family physician, while every throat in the entire class was examined and a culture taken in all suspicious cases. The usual precautions were observed in the class room as regarded disinfection, etc., and for a week and a half the throats of all the children present were examined every morning, no pupil with suspicious symptoms being allowed to return until the culture showed a negative report. Notwithstanding that the epidemic had progressed to such a degree before it was discovered, as a result of these measures no further cases were infected. The same author also reports a similar epidemic of scarlet fever in which the value of medical inspection was amply demonstrated, while the president of the Board of Education of Chicago in his annual report for 1901, states that the schools were saved from an invasion of smallpox by the vigilance of the medical inspectors, etc., and that since it's introduction its efficacy has been apparent from the large number of contagious diseases which have been detected and excluded.

The triple question does medical inspection act as a check upon the spread of contagious diseases? Does it protect against epidemics arising among school children? Does it prevent the infection of others? can be answered in the affirmative by the statement made in the report just quoted, that in one year 5,217 cases of contagious diseases were detected and excluded. In other words, in but one city—Chicago—5,217 cases of epidemics were detected and rendered ineffectual for harm. The Commissioner of Health of Milwaukee states that it is hardly possible to estimate the amount of good that has been accomplished in eliminating cases that were in an infectious stage and thus placing them in quarantine and under proper medical supervision. As an aid in discovering the source of an endemic, or epidemic of these diseases, this system presents somewhat unique features, as the cases are discovered much earlier than they have been without it and by tabulating the cases found it can be seen in what locality they are most numerous, thus following the disease to its original source. Indirectly the inspection of schools has had a most curious and yet salutary effect in showing to the public the necessity for isolation in contagious diseases. This has been noted in various places but in Salt Lake City previous to the partial inspection in force, it was common for the household to scatter between the time of making the diagnosis and the establishment of quarantine, thus increasing the dangers of the spread of the infection. Since, however, this work has been carried on in the schools, the Commissioner of Health has stated that there has been a marked improvement in this respect as in the voluntary reporting of mild cases of contagious diseases. Wherever a number of children are brought into close contact the dangers of dissemination of various diseases must be materially increased and as this is true upon all occasions, it is necessarily so in regard to schools. Efforts are being made of which this is one, to lessen the size of the class and this will of course lessen to that extent these dangers, but notwithstanding this and even granting a model hygienic place of meeting, yet the children come from without and while under such ideal conditions the dangers of contagion are greatly lessened, there remains the fact that as long as contagious disease exists the school must remain an important factor in its dissemination. Medical inspection here finds its especial field not so much in this aspect of being able to keep the surroundings such that disease is kept out of the school, but by detecting and removing individuals with communicable diseases which act as a focus of infection by bringing the disease from the home or street. Another factor which determines the dissemination of communicable diseases, is the necessity of bringing the pupils into close contact within a comparatively small space. This is especially so in the kindergartens and lower grades where the children play certain educational games together and are in many ways through this influence, more likely to acquire contagious diseases than are those in the higher grades. The same thought may also be applied to the fact that the school child is of a susceptible age in regard to contagious diseases, the tendency being greater to contract these affections during this time than at other periods, so that while these factors in themselves cannot be changed even by the most ardent disciple of preventive medicine, yet the dangers of increased susceptibility under such conditions can be reduced to a minimum by the measures which are here advocated.

I have endeavored in part to point out some of the ways in which infection is transmitted in the schools, but only such as seem to be directly concerned with the work of the medical inspector. There are however numerous other means by which various diseases are transmitted from child to child, such as the placing of wraps in close contact or on the floor as is frequent, the common use of books, pencils etc. but while the inspector may enhance his value by detecting such mistakes, yet this applies more closely to other aspects of school hygiene which it is not desired to detail here, although they all bear a close relationship one with the other.

Exceedingly favorable results have been obtained in detecting infectious disease in the homes of school children and thereby preventing its entrance into the school, by having the teacher report to the inspector all children who have been absent from school for four or more consecutive days, or children who have been absent on account of illness, but who are unable to state the nature of the illness on their return to school. In the first class, the inspector on receiving the report of absence ascertains at the home of the child the nature of the illness and if it is contagious enforces the usual rules in regard to quarantine, or in states where compulsory educational laws are in force, the truant officer visits the home to determine the cause of absence from school and in case of illness reports the facts, when the school inspector proceeds as mentioned. Evidence has accumulated to show that this has been of considerable value in eliminating such diseases and in nearly every place where such measures have been enforced, epidemics have been prevented from gaining a foothold. In the case of those returning to school after illness, the problem is a little more difficult as many children return after diphtheria with the Klebs-Löffler bacilli still on their mucous membranes; or after measles while still capable of communicating it to others and after scarlet fever before desquamation has ceased. Where quarantine laws are rigidly enforced such dangers are reduced to a minimum, but still a small number of children return before all danger has passed, while where such laws are lax especially in rural districts, the dangers of propagating the diseases mentioned are correspondingly enhanced. Where the medical inspector acts as an agent of the health board it becomes his duty to examine the child, or certify to a negative culture if possible in cases of diphtheria and until he has certified that all danger of infecting others has ceased to exist, the child should not be allowed to return to school; while the children who have returned after unknown illness should not be allowed to enter the class room until it has been definitely ascertained that they or any one in their family have not suffered from a communicable disease, or in case such is found to have existed, the proper precautions should be enforced until the inspector has decided that it is perfectly safe. Almost daily the inspector will be confronted with cases in which he may suspect the beginning development of an infectious disease, but in which the symptoms are not sufficiently pronounced to enable him to make a diagnosis, tonsilitis especially is apt to produce considerable confusion in this respect, but definite measures should be taken and the child should be debarred from school until the diagnosis either made by the family physician or preferably by culture, indicates the harmless nature of the throat trouble. Too great care cannot be exercised in this respect and it is better to err on the side of safety and temporarily exclude a single pupil, than to expose the entire class to what may be the beginning of an attack of diphtheria.

Practically of the contagious diseases diphtheria is the most serious one frequently encountered and is responsible for many deaths among children of school age. During the census year 1900, there were 16,475 deaths from this disease alone the great majority being children of school age, while the number of cases it is impossible to determine, although thev were undoubtedly over 100,000. No disease is more dreaded in the home and in the school than diphtheria, yet it lies in the power of those in authority to greatly diminish the mortality rate and also to decrease the number of cases by adding in addition to other sanitary measures commonly in force, the medical inspection of schools, so that incipient cases will be detected and early treatment especially the administration of antitoxine will greatly reduce the mortality at the same time also diminishing the tendency to the infection of others. That diphtheria in recognizable stages is comparatively common in the schools can readily be shown by the cases found there. During four months in Chicago, 1,417 cases of diphtheria were located and as the result of this work, the statistics of diphtheria for the year preceding medical inspection and the first year of its operation suggest an important lesson. During 1899 the year preceding medical inspection there were 3,931 cases of diphtheria with 843 deaths, while for the first year of inspection there were but 3,303 cases and 797 deaths, a decrease in cases of 628 with 46 fewer deaths. From January to May 1900, 170 cases of this disease were found in the schools of Chicago, while for the year ending June 30, 1901, 193 cases were found, surely enough to indicate to any thinking mind that this is a serious problem in preventive medicine. Murphy in his recent report found that the prevalence of diphtheria was increased by school attendance and he found that it was the experience of nearly every health officer that the relation between school holidays and a fall in the amount of diphtheria was particularly striking. In four months in Newark 13 cases of diphtheria were found, while in Chicago 747 cases of this disease in school led to the discovery of 26 cases in homes; not receiving medical attention and that were not recognized. That medical inspection is retarding the spread of diphtheria is recognized by the Massachusetts State Board of Health who state that the prevalence of the disease in epidemic form made it possible for the board to introduce three new forces for its suppression namely, antitoxin, the use of the bacteriological laboratory and the third and probably most potent agent is the daily medical inspection of the schools. In Boston for 14 months ending December 31, 1895, 77 cases of diphtheria were found sitting in their seats at school, while in one week in New York 13 cases were found, another week four cases, while from a study of diphtheria in its relation to school attendance in London and Continental cities, Smith found that there was a strong presumption that school attendance is the main factor in the spread of the disease.

While scarlet fever is not near as frequent as diphtheria, yet in the last census year it was the cause of 6,333 deaths, while in those who recover it is the most frequent cause of suppurative otitis and its sequelæ may be seen wherever any considerable group of childeren are gathered together. While in comparison with other affections its numbers in the school seem small, yet on account of its extreme virulency each case exists as a serious focus of contagion and represents the basis of a formidable epidemic. Yet such cases have been found in school, 306 were discovered in Chicago, while a comparison of the number of cases for the years preceding and following inspection showed a decrease of 2,325 cases with 307 fewer deaths following the first year of inspection. The danger from this disease in the schools is dependent to a great extent upon those pupils who have returned before desquamation has been completed. Such cases however should be detected by the inspector and immediately returned to quarantine; no case of scarlet fever under any circumstances being allowed to return until desquamation has entirely ceased. From January to May 1901, the inspectors found 401 cases in the schools, while in other cities it appears to be found in much smaller numbers, 12 cases only being found in nine months in Philadelphia; four cases in four months in Newark, while in Boston for 1900 there were but 23 cases discovered in this way. An instructive lesson in regard to this disease is related by Keen in which 231 cases of scarlet fever were discovered not by the family physician, nor by the parents of the children, but by the medical inspectors and what is especially striking, the detection of these 231 cases at school led to the discovery of 745 cases at home.

Measles, chicken-pox and whooping cough are all considered by the laity to be of little moment and as a result it is of daily occurrence to find children with these diseases regularly attending school. This is especially so in measles and chicken-pox where the eruption is slight and not detected on casual examination, while in whooping cough where the spasmodic outbursts are infrequent, the child is kept at school until he has a paroxysm in the class room which usually leads to his detection. Many health boards do not officially recognize these diseases although measles and whooping cough are responsible annually for 12,866 and 9,958 deaths respectively, a greater mortality in each instance than from scarlet fever. These three affections undoubtedly form a large majority of the acute communicable diseases found in the school and the first two should receive sufficient respect from the authorities both health and educational, to prevent the annual outbreaks which are initiated a few weeks after the beginning of each term of school. That these diseases are prevalent and attend school daily, can readily be seen by the following figures. In Boston in 1895, there were found 28 cases of chicken-pox, 116 of measles and 33 of whooping cough, while for 1900, 121 cases of measles, 108 of chicken-pox and 62 of whooping cough were excluded by the inspectors. In New York City in two weeks, six cases of measles, four of whooping cough and 23 of chicken-pox were found, both measles and chicken-pox being recognized as contagious diseases by the Board of Health, quarantined accordingly and are not allowed to return until recovery has ensued and the premises have been disinfected. In Chicago in 1896, 46 cases of measles in the schools led to the discovery of an epidemic of this disease in several sections of the city, while for the school term of 1900-1901, there were found in attendance 434 cases of measles, 626 cases of chicken-pox and 195 individuals suffering from whooping cough. While in the same city from January to May 1900, the inspectors discovered 648 cases of measles, 55 of whooping cough and 670 of chicken-pox and in Philadelphia during one term, the inspectors found 152 cases of measles, 73 of chicken-pox and 20 of whooping cough. As regards these three diseases alone, medical inspection deserves respectful attention at the hands of sanitarians. As directly relating to this subject, the influence of measles upon school life has been studied by Schafer who found in four years in Schleswig-Holstein that the schools had to be closed 82 times on account of epidemics of measles and on several occasions they were closed on account of a lack of sufficient scholars to attend, nearly all being ill from the prevalence of this disease. While Armstrong the medical health officer of Newcastle-upon-Tyne closed all the schools for four weeks on account of the prevalence of measles and whooping cough and the epidemic was suppressed, while during a similar epidemic the following year, the experiment was tried of closing each school where scholars were taken ill only long enough to allow of disinfection and it was found that as far as measles was concerned, it was followed by its extinction. In one school in which there were 44 cases in three weeks preceding disinfection, after the first two weeks the number fell to three in 13 weeks.

So few cases of tuberculosis especially the pulmonary form have been found, that for practical purposes little attention need be given it here. When a case is discovered however I believe the inspector should advise that the affected child should not be allowed to remain in school and this for two reasons; first because healthy children should be protected from this disease and the second reason which seems to admit of little argument, is that for the best interest of the child it should be placed under conditions favorable for the cure of the disease if such are possible and therefore should not be allowed to remain in school where it must inevitably forfeit its life for a partial education which will necessarily be of no value to it.

As regards the contagious diseases previously mentioned and more especially diphtheria, medical inspection has proven of not only a direct but also an indirect value, by in many instances, shortening the period of quarantine placed upon the case and this has resulted from the early detection of the disease in school and thereby the material shortening of the course of the disease by prompt and early treatment, especially is this so since the introduction of antitoxin. Anything which will exercise a prophylactic influence regarding contagious diseases has not only a vital but also an economic value, for among the poorer classes quarantine usually means the difference between independence and pauperism and even the small scale in which medical inspection now exists, has done much to protect the school child from these communicable diseases and therefore has to many families meant independence at home and not a long period of want and privation. Further, inspection not only as regards contagious diseases but the entire class of affections found in school children, aids materially the chances of recovery by detecting acute diseases in their incipiency and therefore allowing of prompt treatment, at the same time removing the child from harmful influences. In contagious diseases it has caused in some places a better understanding among parents of the necessity for isolation and while this is essential in the suppression of this class of diseases is no doubt constantly being evaded, yet from the testimony of those connected with medical inspection in one way or another, numerous instances have occurred in which previously a contagious disease was not reported. but after the effects of this measure had been but partially demonstrated, the presence of another case of diphtheria for instance in the same family, was promptly reported. Isolation has also been aided by these means, as many of the cases are diagnosed in the school and therefore placed under the control of the health authorities as soon as the child reaches home, thus absolutely preventing the least pretense of evading quarantine measures.

As many of the states are adopting compulsory educational laws and therefore of necessity require truant officers, the employment of these officials as an aid in medical inspection has proven of added service especially in Chicago, where the medical inspection of schools is under the control of the Compulsory Educational Department. This is a new feature in inspection work but the truant officers have unexcelled facilities for detecting cases of contagious diseases in the homes of the school children and if this system is utilized, it will add greatly to the efficiency of the inspectors in detecting disease. The principal of the school reports to the truant officer all pupils who have been absent for four or more days and whose cause of absence is unknown and if on investigation the truant officer finds that there is illness in the house, a report is made to the principal of the school and the Board of Health, and in case the disease is found to be contagious, the children from the address where the disease existed are excluded from school until all danger has elapsed. That this work has been of added gain to medical inspection is shown by the detection of 2,706 cases of illness found by the truant officers during the school year of 1899-1900.

By removing many sources of contagion in communicable diseases and by detecting physical defects and various ills in the scholars, the interruption of school work through illness is reduced to a minimum. Of course it is impossible to estimate with any degree of accuracy the number of days of school attendance gained by the child as a result of medical inspection, but it must be considerable especially as the result of detecting defects of the special senses, where correction means days at school which had been lost in the past by headaches from eyestrain or frequent attacks of coryzia and acute inflammations of the upper air tract from the presence of enlarged tonsils, adenoids, etc.

An important aspect of medical inspection that has been much neglected is the examination in the lowest grades especially the kindergarten and allied classes, of the younger children. On account of the frequency of communicable diseases among children varying from five to ten years of age, especial care is necessary to prevent the infecting of many from one or more sources and while the so-called school diseases have not to any great extent developed at this time, yet the detection at an early age of eye or ear defects or abnormalties of the respiratory tract, is of paramount importance and in addition to a physical examination at least once each term, daily inspection for the purpose of preventing various diseases from getting a foothold is most imperative. This is demanded not only as a general preventive of disease as among the higher grades, but is markedly so on account of the methods employed in teaching and amusing these children, as they are brought into close contact one with another and in many ways the opportunities for development of contagious diseases are here greatly enhanced.

As has been stated by Wright, medical inspection, if properly performed, seems to offer the best chances for lessening sickness in school children, and this statement seems well borne out in the comparatively short time that inspection has been in existence in few cities. As regards diseases of the eye, ear, skin, upper respiratory tract, etc., a marked decline in the number of cases found in the schools must be self evident, as the majority of these affections respond readily to treatment and of necessity their detection by the inspector with the recommendation that the child is in need of medical advice, seems to be heeded by many parents with the resultant removal of the defects. New cases are constantly developing however and these in addition to those not cared for and new pupils entering the different classes, constantly adds to the number to be investigated by the inspector. In Chicago the result of this care of the school children has been a notable decrease in the mortality of diphtheria and scarlet fever as shown by the first year's work, when there was a decrease in the number of diphtheria cases of 628 for the year, while scarlet fever showed a decrease of 2,325. The records of the Health Department of Chicago showing a material decrease in contagious diseases among children, since medical inspection of schools was established. The same results have also been noted in other cities, while in Philadelphia for the month of January 1900, 480 cases of sore throat were reported, yet under school inspection for the following seven months there were but 1,040 cases, showing an average monthly decrease of 330 cases. Such a decrease also being noted in Newark, where the decline in the number of cases examined as well as in the number excluded from month to month, shows the good results of careful medical inspection.

One of the earliest facts which drew the attention of investigators to the health of school children was the predominance of eye affections and as a result, probably more attention has been directed along these lines than to any other affections of the health, until very recent years. Ware as early as 1812 showed that the school-room was a frequent cause of myopia and undoubtedly from the early recognition of eye defects in school children, medical inspection had its inception and gradual evolution It is impossible here to more than outline what has been done for the eyes, what has been found and to consider the subject briefly in its relations to the medical inspection of schools. As regards the eye affections of school children, two broad classes may be differentiated for practical purposes, first, those diseases contagious or infections in nature of which purulent conjunctivitis is an example and which should be grouped with such diseases as erysipelas, ringworm, diseases of the scalp and scabies and in which the affected child should be excluded from school until cured, but differing from diphtheria, measles, etc., inasmuch as only the child affected is not permitted to attend school instead of this latter group of diseases, where all children in the same house are also excluded. These contagious eye affections are common in the schools and unless properly handled, give rise on frequent occasions to more or less disseminated epidemics. Their frequency may be judged from the fact that 55 cases were found in the Chicago schools during a period of four months; 113 cases were found in Boston in 1900; in 1890-91 an epidemic of follicular conjunctivitis in the schools of Dresden affected 10,000 children; 87 in New York in two weeks; 397 in Philadelphia in nine months and in Newark in four months 289 cases were found.

A more complex problem and one which has a great influence on the career of the pupil, is the various changes in the eye affecting the sight and accommodation. While tests sufficient to determine the presence or absence of a visual defect do not necessarily require the experience of an expert to properly perform them, yet they should be made by the physician to obtain the best results: as it is however this is usually performed by the teachers and even under these conditions the number of children with marked visual defects is somewhat enormous. In Philadelphia where this work has been in existence but a few months and therefore no statistics are available, the eyes are examined by means of suitable cards and a record is kept which will follow the child through its entire course at school. Similar methods are in force elsewhere and the results especially in Cleveland, have amply demonstrated the worth of the system. Previous to this in the former city, the medical inspectors found over 1,000 cases of defective vision, while the inspectors in Boston for 1900 found the following eye diseases in daily attendance at school: foreign bodies, 13; blepharitis, 23; stye, 14; ptosis, three; obstruction of lacrymal duct, four; diseases of conjunctiva, 113; interstitial keratitis, three; ulcer of cornea, 13; opacity of cornea, seven; iritis, three; stabismus, 12; nystagmus, three; imperfect sight without visible cause, 220; a total of 431 cases undetected at home, neglected and yet previous to inspection expected to be on a par with healthy pupils. Defects in sight are essentially the result of conditions at school, this of course does not imply that the sole cause of eye defects is the school, but many originate, others are increased and all may be rectified here. That school has a marked influence for harm upon the eye has been shown by the Swedish Commission, who found an increase in near sight from six in the lowest to 37.3 per cent. in the highest class and it was also found that this increase bore a direct relation to the length and amount of study. This is also shown by the researches of Cohen who in an examination of 10,000 children of all grades found one per cent. of myopia in country schools; 5.11 per cent. in elementary schools; 20.40 per cent. in grammar schools and 30.35 per cent in colleges. In 1896 Carter found among

8,125 children in the London schools, that only 39.15 per cent. presented normal vision. In the schools of this country the same results have been found and an abundant literature exists on this subject which it is unnecessary to quote here, but Calhoun found from the reports of examinations of 45,000 children, that near sight increases from nothing in the lowest to 60 and 70 per cent. in the highest classes. While in the Buffalo schools the percentage of visual defects increased at seven years of age from five, to 26 at 18 years and of the graduates of the high school 25 per cent. were near sighted. In the schools of Brooklyn the eye examinations showed that about one-third of the entire number examined were defective in this respect, varying in some districts to as high as 50 per cent., while in more favored localities was as low as 12 per cent. The deleterious effect of defective sight was also found in the fact that one-half of those deficient were above the average age of their grade, so that it is apparent that often the supposedly stupid pupils who make little or no headway in their studies are those incapacitated on account of defective vision.

Special attention has been given to the eyes in Cleveland and as a result of the examination of 32,939 pupils it was found that 6,169 or 18.7 per cent. had some defects. It is unnecessary to mention isolated instances of defective vision in its relation to school work, but many cases could be cited where the child made a failure in his studies until someone in school discovered that he could not see them when proper treatment had been applied, he would keep well up in the class and even outstrip the others previously considered his superior. This condition has been to a great extent remedied in a few cities, but only in a few and only a small number of children have derived the benefit, but under an efficient system as a part of medical inspection, the future of many a child would be materially brightened. The studies of Butler seem to sum up this matter of visual defects of school children in a most admirable manner; he says that refractive errors are extremely common being present in as high as 50 per cent.; these errors are of great importance on account of the immediate symptoms and disabilities which follow their neglect; they are important factors in the production of many painful and disabling affections common enough in childhood, but still more so in adult life; and their early correction is demanded not merely as a means of therapeutics, but as an important measure of preventive medicine.

Of the minor group of diseases as regards numbers which has come to the attention of the inspector, diseases of the ear and especially those attended with impairment of hearing have suggested the importance of detecting the defects on account of the harmful influence exerted upon the pupil. Suppurative otitis media is quite commonly found in the school but bears no relation in its etiology to school work and is of importance to the medical inspector inasmuch as its detection is often followed by a complete change in the attitude of the pupil toward his studies. Unlike eye defects impaired hearing has no effect upon the general health of the individual, but it does seriously impair his ability to properly perform his school work. An illustration of this which may be duplicated more or less frequently in quite a number of schools, being related by A. K. Whitcomb, of a boy 13 years of age and still in the primary grade, utterly incapable of making any headway in his studies. On investigation it was found that his hearing was defective and by giving him proper care his success was phenomenal, as he soon outstripped those who were believed to be far his superiors. In Newark, 27 cases with suppurating ears were found in the schools; 87 in Philadelphia were deaf or had some ear disease; 87 were found in Boston, while from studies made by six observers, an average of 20.33 per cent. were found to have some impairment of hearing. Sexton found 13 per cent. had partial deafness and of these only three per cent. were aware of their difficulty in this respect. In the few places such as Cleveland where some attention has been given to the hearing, the tests have been made by the teacher, a practical method being that of Gale, by which the pupil with chalk in hand stands facing the blackboard and the teacher dictates isolated numbers or words which the pupil writes on the board. Should he not be able to hear properly, this will be readily detected. While this method is fairly satisfactory and enables a rough estimate to be made of the hearing capacity, yet it is far better to have the medical inspector make such examination of the pupils at the beginning of each term in conjunction with the visual examination and from time to time thereafter of all new scholars and of those suspected of having hearing defects.

Defects of breathing or chronic inflammations of the upper respiratory tract are exceedingly common and when of small degree apparently exercise little harmful influence, yet they have a tendency to increase in severity and also to be augmented by unhygienic surroundings. The child with enlarged tonsils or a naso-pharynx filled with adenoids is not capable of doing good work and the results of proper treatment of these cases, amply justifies the work of the inspector in detecting the disorder. Another factor which these children present, is the increased susceptibility which they afford to the dangers of contagious diseases, especially is this true of diphtheria and the child with catarrhal processes of the air passages, enlarged lymphoid glands of tonsils, not only is more liable to contract these contagious affections than is the healthy child, but his chances of recovery are also much less. As a result of the first year's examinations in the Boston schools, diseases of the throat constituted a large proportion of the diseases found in the children and 1,749 were so affected, while of 8,964 pupils examined at a later period, 3,934 suffered from oral and respiratory diseases. Durgin has forcibly called attention to the excessive prevalence of diseases of the respiratory tract in school children and he found that of 9,188 examined, 5,689 had acute or chronic diseases thus located, while for the year 1900, the inspectors found 2,609 oral and respiratory diseases; four months inspection in Chicago resulted in 689 cases of tonsilitis being found and at a later period 788 children were temporarily excluded for the same cause.

Among the conditions found in large numbers by the inspectors, parasitic and skin diseases have been especially prominent, in Chicago during the first few months of inspection, 193 cases of impetigo, 241 of pediculosis, 76 of ringworm and 48 of eczema were found, while in one year 1,289 such cases were denied attendance at school. Boston schools in 1900 contained 3,421 cases of all kinds of skin affections and so common is pediculosis, that the usual rule of referring the child home for treatment is abrogated and in addition to a special card to the parents stating the conditions, it also contains printed directions for killing the parasites accompanied with a printed prescription for petroleum to be used for this purpose. From October 1, 1901, to February 1, 1902, there were found in the schools of Newark 1,041 children with these affections, the greatest number being those classed as vermine of which there were 861 cases excluded, while in Philadelphia within a few months 1,282 cases of skin and parasitic diseases were found, the majority of which were communicable. So prevalent is it for these affections to be brought into the school and there disseminated especially by the uncleanly and poorer class of people, that quite extensive epidemics are occasionally produced.

Where the system of medical inspection is thorough and contemplates a complete supervision of the health of the pupils both as regards diseases that may be brought into school by them and those which may develop as the result of being at school, in contradistinction to inspection which has for its objects purely the elimination of contagious diseases, a group of so-called school diseases will come under the considertion of the inspector and demand considerable tact and patience before appreciable results will have been obtained. Such a group comprises the milder grades of spinal affections and a very large group of nervous affections or neurasthenic symptoms, the causes being as varied as the individuals that make up this class and cannot be noted here except that over study and improper posture are responsible in many instances. Mild grades of spinal deformities are largely incident to school life especially between the age of six and fourteen years and it is probably present in at least 10 to 20 per cent. of school girls; while frequently accompanied with nervous disorders, headache, etc., it naturally keeps the affected individual handicapped and should be carefully watched for both by the teacher and the inspector. In 611 examinations Guillane found 30 per cent. affected with curvature of the spine, while in the schools of Cleveland a large percentage was discovered in the grammer grade rooms. As regards neurasthenic symptoms an increase approximately of from five to 50 per cent. has been found from the lower to the higher grades, so that by careful observation and suitable suggestions the inspector is capable of doing an immense amount of good in this single field alone. The very familiar "nerve sick" school child is unfortunately too common; in England, Warner found 11 per cent. and among the school children of New York, Hamilton found 20 per cent. with various neurasthenic phenomena, while in the higher schools of Moscow nearly 70 per cent. had some nervous malady.

Other diseases characterized by prominent nervous phenomena are also found by the medical inspector and are of import not only to the affected individual himself, but have a most demoralizing effect upon the children with which he is in contact. Epilepsy, chorea, etc., are the diseases to which I here wish to refer and while they exist in the school in but small numbers, yet for the sake of the individual and of those forced to witness paroxyms of these affections, they should be placed under other aspects than those of the public schools. An observer in Springfield (Mass.) found an epileptic and a typical moral degenerate in a single school room and the same observed justly says "right in the public schools is the successful fight against crime, insanity, epilepsy and feeble mindedness to be fought and the battle won, if properly waged." While another observer while in a well-kept school room, was suddenly startled by the sound of a falling body due to one of the scholars having an attack of epilepsy, which was of frequent occurrence. That these are not isolated cases and that such affections are present in the schools is shown by the medical examiner of Salt Lake City, where with but a single man doing the work and necessarily at infrequent intervals, five pupils mentally deficient were found and a girl suffering from epilepsy had to be excluded on account of the consternation produced by her attacks and the general unrest occasioned by the fear of their recurrence. While in Boston during 1900, there were found 14 cases of chorea and six of epilepsy and in Newark five cases of chorea were found and in both these places no special investigations were conducted for nervous affections.

A further duty of the inspector is his determination by personal examination of the presence or absence of a successful vaccination cicatrix on every child admitted to the school. In many places during the past three years on account of the prevalence of variola, this has been insisted on from time to time and its enforcement depends upon two factors, first the nature of the legal requirements in the city or state and secondly, the medical inspector. The future presence or absence of smallpox in this country will undoubtedly to a great extent be influenced by the successful vaccination of school children, the good effects observed from this measure being those due not only to the exemption of the school population from variola, but many parents are thus influenced favorably and will be vaccinated when they had refused before. As as essential requisite for entering school, vaccination should have the same place as other necessary requirements and should be legally insisted on.

One of the many indirect results of medical inspection especially where it has embraced more than the detection of communicable diseases, has been the effect upon the personal hygiene of the child, children who came to school unkempt and often unclean despite the efforts of the teacher to improve their condition, gradually improved in their personal appearance not only at school but they were also more cleanly at home. While this may in itself appear to be a trivial matter, yet it makes a considerable difference as regards such affections as pediculosis, skin disease, etc., and after the pupils realize that the efforts of the inspector are directed toward their good, the number of such communicable diseases will decrease to a great extent. While medical inspection has thus been of value in improving the personal hygiene of the scholar, it has also been of benefit to the teacher in enabling her to remove ill scholars and by detecting physical defects such as those of sight and hearing. It is surely easier to teach a normal individual than one ill, or unable to see or hear normally and for every child that has been helped by the detection and removal of these defects, the work of the teacher has been correspondingly lessened. It has also instructed her in various aspects of school sanitation and as she is necessarily a foster parent of the children under her care for the better part of the day and often a better foster parent than the real parent at home, by increasing her ability to detect an ailing child, the results have been most beneficial. What has been said in regard to the teacher and the pupil is also true to a considerable extent as regards the parents. Instances are continually being presented where a parent antagonistic to the measures at first, has soon seen their value and not only endeavored to detect the early signs of illness in their children at home instead of sending them to school, but the interest of the parents has been gained and a decided step has been made in showing them that preventive medicine has a place not only in the school, not only something which immediately concerns the physician and sanitarian, but it is an essential factor in the home.

In carrying out the ideas embodied in a system of medical inspection of schools, the relation of the individual scholar to the means employed for his education are considered as bearing upon his physical welfare and to obtain the best results from the educational point of view, the physical strength of the individual as regards his routine work must be taken into serious consideration. As has been well said "education gained at the expense of health is a loss," yet each year many children pay the penalty by their lives and many thousands more by serious illnesses. In addition to inspection being a direct, practical and economical method of saving life, it is also of immeasurable value in demonstrating to the mass of people the necessity of preventing disease. In the majority of public schools little or no efforts are made to give instructions towards conserving health and detecting the early stages of the common and often fatal diseases, Michigan has however recognized the necessity for this measure and the so-called "Michigan idea" will well bear copying elsewhere. It consists essentially as a result of the law passed several years ago that "there shall be taught in every year, in every public school in Michigan, the principal modes by which each of the dangerous communicable diseases is spread and the best methods for the restriction and prevention of each such disease." The state board of health sends annually to each public school superintendent and teacher in the state, such printed information as will enable them to comply with the instructions of this wise law. Such a valuable measure in connection with medical inspection as here advocated, would without the least doubt be the means of preserving many lives which are annually lost for the want of such measures, without considering the enormous financial gains to the state.

Any measure which will preserve the resisting power of the individual against disease, is essentially based upon as sound a principle of prevention as is that which for the same reason, endeavors to keep disease away from the individual by preventing him coming into contact with cases of that particular affection. The tendency of the school leads in many instances to the physical deterioration of the pupil and while educators and sanitarians have been and are doing much to make the school surroundings as near ideal as possible, this factor of physical deterioration with its necessarily added risk of lowering resistance, still remains a force to be combated.

Thirty-two States and Territories have compulsory educational laws which compel the child beginning with its sixth, seventh or eighth year to begin its education, the vast majority in the public schools. The state in its relation to the school population thus taking the stand that the age factor is the sole requirement to begin school life and makes no provision for the safeguarding of the child from the communicable diseases with which laws compel it to be brought into almost daily contact. Many children present constant evidence by their impaired physical condition and by attacks of measles, whooping cough, diphtheria, etc., the latter group of diseases beginning to rapidly increase at the opening of each school term, that the age is not the only requirement necessary to commence school attendance. Education implies more than mental development, it also implies physical care and protection and while many communicable diseases will always be present in any community, yet the state should realize that health is a condition of citizenship and protection of the health of its child population, implies a better class of citizens for the future than would be the case were such protection not afforded. The State provides for its paupers who return nothing to it, it makes provision for their physical welfare, it protects them from communicable diseases, yet the school child the support of the State in the immediate future, receives no such care as is given to even the meanest pauper, while for a small outlay a system of preventive medicine could be inaugurated and supported, whose benefits both direct and indirect would effect a salutary influence over the entire populace.

Many a child dull, inattentive or apparently negligent in his studies, is punished for his seemingly continuous neglect and yet the experience derived from medical inspection has shown that the majority of these scholars have been so by reason of some physical defect especially of the eye and ear, the correction of which transformed them into bright, ambitious children. When it begins to be more fully realized that preventive medicine insists on a physical basis of education and that such a system reduces the penalties of education, then will punishment versus physical examination in the schools be a much easier problem than it is at present. In many ways preventive medicine has in the past few years taken a prominent position in the public school system especially from the hygienic aspects, such as the housing of the children in modern sanitary and well-lighted buildings, the diminution of the size of the class thus in a manner decreasing the tendency of close contact of large bodies of children, and also by the recognition of the individual and the adoption of other safeguards against disease, such as medical inspection. Whatever measures may be adopted to reduce both the morbidity and mortality of the school child, must be initiated in the school and the results will soon appear in the home. Medical inspection is not only a duty but it is a privilege, a privilege not limited to a class small in numbers, not to a single disease, but directly bears upon the health of over 20,000,000 individuals and by lessening disease among these, indirectly concerns the entire population and is directed against practically all acute and many chronic diseases which affect not only the child but also the adult. Public safety thereby as regards endemics or epidemics is a great gainer, not only by the prompt recognition and isolation of communicable diseases which medical inspection affords, but also by its educational benefits, is the community at large benefited.

Quite suggestive from the economic aspect is the relation between medical inspection and the extent of losses due to preventable ill-health and deaths. There can be no gainsaying but that preventive medicine adds vastly to national wealth both in the saving of life with its earning capacity and the lessened cost of fighting disease, as preventive measures become more generally adopted and the results become more apparent. While a low estimate of the value of a human life would be $1000, yet should one-half this sum be taken for such purposes, the saving of lives by properly exercised medical inspection alone, would be the means of placing a vast sum to the credit account of the nation. Another side of the economic aspect is furnished by the early detection and isolation of cases of contagious diseases such as diphtheria and scarlet fever and thus by greatly diminishing the number in this way, a financial saving of no small magnitude is effected not only to the individuals quarantined, but also to the health boards who expend considerable sums in effecting such measures. Disease means loss of money and medical inspection by reducing the number of cases of communicable diseases, means the reduction of this loss to a minimum. Wherever paid medical inspection has been tried it has proven to be a sound financial investment and instead of acting as a drain upon the public treasury, the reverse has been found to be the case. In New York City where inspection does not go beyond the detection of contagious diseases, it has "more than saved an excess in the value of coffins for the potter's field, to far more than pay for the expert service." The inspectors of Boston receive $200 a year; of Chicago $50 per month; and of Newark $250 per year, these figures representing the usual average cost per inspector, the total cost varying with the number employed. Wherever the system has been in operation the cost has proven to be comparatively small, while in Milwaukee the Commission of Health stated that the expense seemed so infinitely small in comparison with the enormous amount of good resulting therefrom, that it seems utterly impossible for any person to raise objections on this account.

Like other measures which have a direct bearing upon the prevention and transmission of disease, objections have from time to time been offered, but in the light of its successful operation have been found to be groundless. The principal objection being the cost but as just stated, experience has shown that it more than pays for itself. Other objections raised against it have been the supposed interference with the family physician, with the duties of the teacher and her control over the scholar and the interruption in the school routine each day by the coming of the inspector. It is unnecessary to more than briefly enumerate these, as they have all proven groundless and it has been the experience of those doing this work that both the teacher, the parents and the family physician have recognized its value within a short time after the inauguration of the service and have all aided in the movement. Finally as the success of the measure is to a considerable extent dependent upon the joint action of both the school and health authorities, it has been thought that it would be impossible to have both bodies act in harmony, but the reverse has always proven to be the case and as yet no valid objection of any weight has been offered against it. It is of interest in this connection to also note the legal status of medical inspection, as out of 76,805 examinations made in Chicago, there was but a single lawsuit instituted by parents and in this the only instance which I have been able to discover, Judge Ball of the Superior Court decided that the medical inspection of schools was constitutional and the rights of principals and medical inspectors to exclude pupils for cause, was upheld, the case not being appealed.

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